POWER

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Purposeful Anecdotes

Why Boys Leave Home

WHY is the young engineer, brought up in a small town, usually more successful away from home? It is a peculiar fact that a small town or a plant owner in such a town will often hire a stranger to run the plant in preference to "home talent."

I quote here from a newspaper, and being familiar with conditions and knowing the "boys" referred to, am sure this is just another case of the common notion that strangers can run our business better than we can. The newspaper says:

> It seems to the "Register" that it is about time the city hired a competent man to take charge of its power plant. This plant is too valuable a piece of property and the work carried on by it is too important to the city to leave it in charge of boys. What the city really needs and what we believe it will have in time is a manager for all of the city utilities. The plants have always made money in spite of poor management, but they could make more and give better service were they under one competent head. Let the city employ a man of the caliber of J. H. Roberts and there would be some system and management to the city's affairs where there is none at present. We don't know whether Mr. Roberts would take the position; the chances are that he would not; but the city needs some man of like ability and needs him badly.

The "boys" are technical graduates, which is not conclusive proof that they are good managers, but they are not at fault for the laxity of the city aldermen who have failed to appoint a new manager. The city once had a manager, but he left for greener fields, and the "boys," who had virtually grown up in the plant and who knew every nook and cranny in it, were naturally retained to run it. While there should be a manager, and good managers can be obtained from hundreds of out-of-town cities in the United States, I can see no good reason why that man must come from some other city.

The trouble is these "boys" grew up in that town. The editor, a nonmechanical elderly man, looks upon them as "mere boys," and he always will, overlooking the fact that these selfsame young men could go into almost any other small town and successfully take charge of even a larger plant requiring more skill and executive ability. And residents of this strange town would call them "men" and "geniuses" instead of mere boys. These men work hard, and, as the newspaper admits, the plants are making money, but the editor will never be satisfied until someone of the ability of J. H. Roberts (who came to that town a stranger) is put in charge. And they will pay the new man a larger salary. Usually when a "boy" or "fossil" is put out the successor is paid a larger salary regardless of his competence.

As it happens I was raised in the city in question myself and therefore know what these "boys" are up against. I had worked there in a power plant and was familiar with it. I worked in it during my summer vacations. During the remainder of the time I went to school and college. I was graduated, and at the first opportunity applied for the advanced position which was vacant in that plant at the time. But I couldn't land the job. The owner said, "What, put that kid, son of old Sim Wilson, in charge? Nix! What does he know? We'll get an experienced man."

I sought employment out of town where I was not so well known, and, as so frequently happens, began with a larger salary than I would have received in my home town. I "made good" from the start in the strange town. A few years later, as the preachers say, I received a louder "call" from another strange town, where I made good again. It seems that after one becomes acquainted with the inhabitants of a small town he diminishes in their estimation to the extent that he does not deserve an increase in salary. He becomes a sort of member of the family and is expected to do all he can for everybody else and make a bare living for himself.

This seems all wrong. But isn't it a fact that you yourself underestimate the ability of your assistants after you have become familiar with their ways after years of association? I admit that I am guilty of the same fault, and it is certainly a fault. Nothing would have pleased me more could I have stayed at home, in my small town, and worked up into such a managership as the above editor wants to give to a stranger. This explains, I believe, why I left home.

Contributed by S. F. WILSON, *New York City*

Union Central Building Power-Plant Tests

By C. B. Garrison*

SYNOPSIS—Account of tests giving an idea of the precautions taken by Capt. M. W. McIntyre, manager of the Union Central Building, to obtain efficient operation in the engine and boiler rooms.

The Union Central Building, the home of the Union Central Life Insurance Co., Cincinnati, Ohio, is the tallest building west of New York City. Tests to determine the cost of producing steam and electric current were recently made by the author with the results given in the following which may be of value to engineers of office buildings in checking the results obtained in their individual plants.

The first experiment was to determine the evaporation test on two of the four 250-hp. Heine boilers, with furnaces equipped with Murphy mechanical stokers. The test was made under regular working conditions, starting at 8 a.m. Oct. 26, 1915, and quitting at 4 p.m., a period of eight hours.

The Kentucky coal used in this test contained 14,000 B.t.u. per lb. The boiler room contains standard platform scales to weigh the coal taken from the storage bins and delivered to the stokers. The amount of coal fired during the test was 12,103 lb., the percentage of moisture being 3.05. Subtracting the amount of moisture in the coal, it left 11,733 lb. of dry coal, or an average of 1,466.73 lb. of dry coal consumed per hour. The amount of dry coal consumed per square foot of grate surface was 17.46 lb. per hr.

How Feed Water Was Measured

To determine the amount of water evaporated, two large tanks were procured and measured to find the exact amount of feed water they could contain, and a tabulation was made as each one of the tanks was emptied and refilled. The water evaporated under actual working conditions per pound of coal as fired was 8.70 lb. The equivalent evaporation from and at 212 deg. F. per pound of coal, as fired, was 9.109 lb. The equivalent evaporation from and at 212 deg. F. per pound of combustible was 10.50 lb. The total ash and refuse was 1,239 lb.; the percentage of ash and refuse in the dry coal was found to be 10.55.

The water-heating surface in each boiler is 2,456 sq.ft. The total weight of water fed to the boilers was 105,308.3 lb., making the factor of the evaporation 1,047. The equivalent evaporation in dry steam from and at 212 deg. F. was 110,257.79 lb. The water evaporated in this test per hour from and at 212 deg. F. was 13,782.2 lb. The equivalent evaporation per hour from and at 212 deg. F. per sq.ft. of boiler-heating surface was 2.81 lb., and the average temperature of the feed water entering the boilers was 214 deg. F. The equivalent evaporation from and at 212 deg. F. per lb. of dry coal was 9.39 lb. The average steam pressure by gage was 148.7 lb. The average temperature of the escaping gases from the boiler was 554 deg. F. The average furnace draft was 0.1985 in. on the water-draft gage. The stack draft indicated 2 in. by a U-tube water-draft gage.

The horsepower developed in the two boilers was 399.5, giving an approximate boiler efficiency of 67 per cent.

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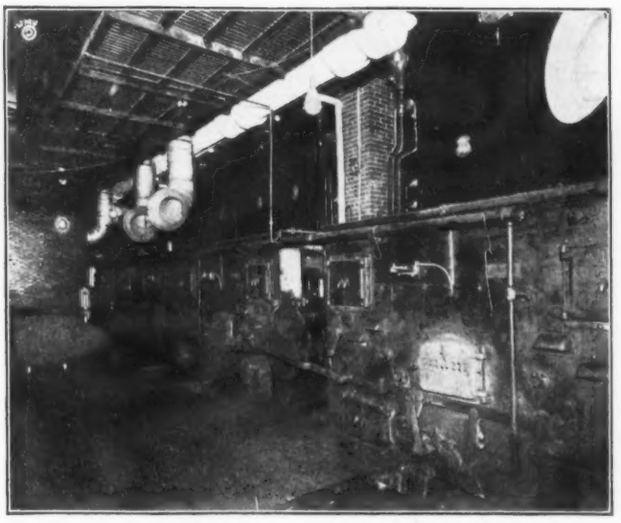
The rating of the boilers by the builder was 250 hp. each, or a total of 500. When making the test, the steam required was not sufficient to keep the boilers working up to the builder's capacity rating.

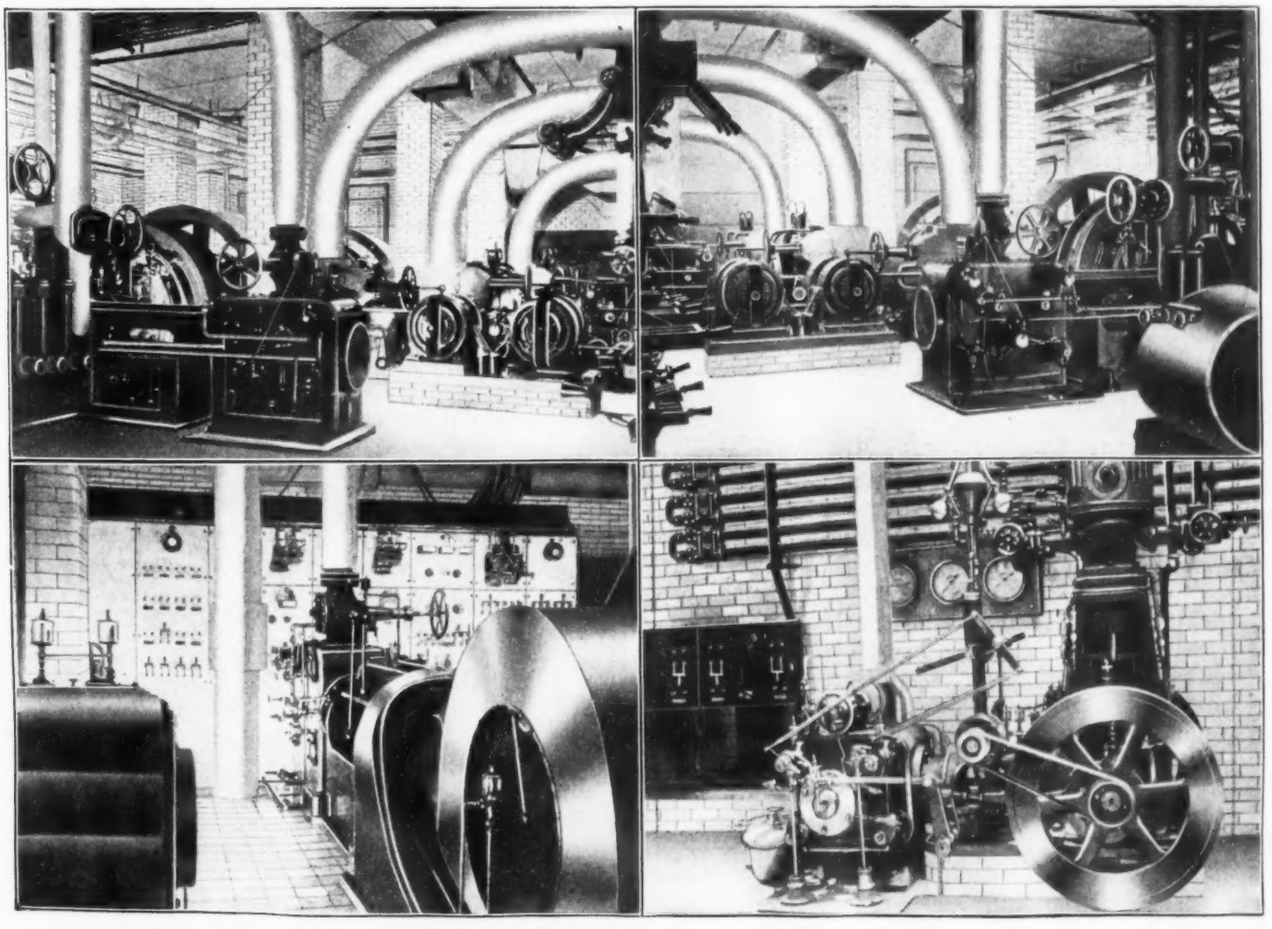
Fourteen samples of the coal were taken at intervals during the 8-hr. test, as the coal was fired, and were analyzed by a chemist. The results showed that the coal contained 13,443 B.t.u., with 9.81 per cent. ash. The coal used in this test cost $2.19 per ton delivered to the boiler room. It cost to evaporate 1,000 lb. of water from and at 212 deg. F. at the rate of $0.1201. With coal at $2.19 per ton, it cost at the rate of $0.001095 per lb. of coal. In making this test a Riley two-pass closed feed-water heater was used. The boiler-feed pumps are controlled by Mueller governors, thus automatically controlling the boiler feed.

The cost of producing electric current during the 8-hr. test was as follows—Fuel, $13.25; help (fireman, engineer, an oiler and a coal passer), $6.61; engine oil, $0.26; cylinder oil, $0.30; waste, $0.18; boiler compound, $0.06; oil used in boiler room, $0.10; water, $1.35; total, $22.11.

There is to be a credit allowed to the foregoing account for the steam furnished for the house pump, for heating water, for the ice plant and other auxiliary equipment to the amount of $2.74, making a net cost of $19.37 to produce 1,280 kw.-hr. for the eight hours. On a basis of these figures, it cost $0.015, or 1½c. to produce a kilowatt-hour at the switchboard. It costs $0.015 per kw.-hr. when all steam is utilized, for producing electric current, which is about six months of the year; the other six months the exhaust steam is used in heating the building. The returns are handled by a vacuum pump, which discharges the condensed steam back to the boiler room. Since, if there were no electric-light plant, it would be necessary to heat the building with live steam during the winter, in these six months there should be a credit allowed to the current produced, and figuring this on the basis of 8 hr., it would cost $5.75 to produce 1,280 kw.-hr., or a kilowatt-hour would cost $0.00447. During the six summer months, a kilowatt-hour would cost $0.015. Therefore, the average cost per kilowatt-hour is $0.00973 for the current produced throughout the year.



A VIEW OF THE BOILER ROOM



VIEWS OF THE ENGINE-ROOM APPARATUS

Following are the details of the test on three Goubert hot-water heaters installed for heating the hot water used throughout the building, at the washstands and the slop sinks. The water enters the heater at 72 deg., and the average temperature of the hot water delivered to the fixtures throughout the building is 138 deg. There are in the building approximately 275 washstands and slop sinks or fixtures supplying hot water to the tenants.

During the eight hours of the test, it is estimated that 2,494 lb. of steam was used in heating water for the building, or an average of 311.8 lb. per hr. The cost of producing hot water for eight hours was $0.2961, making the cost per hour $0.0370. The cost of heating water per fixture averaged about $0.00108.

The Worthington, 8&12x6x12 boiler-feed pump during the 8-hr. test required 3,296 lb. of steam to pump 105,308.3 lb. of water into the two boilers against a steam pressure of 148 lb. One pound of steam delivered to the boiler an average of 31.9 lb. of water, an average of 412 lb. of steam being used per hour. The boilers required on an average of 13,163 lb. of water per hour.

During the test the coal required to produce and make steam for the pump was 362.2 lb., the cost of coal was $0.3966, and it cost $0.0312 to pump 1,000 gal. of feed water into the boilers.

A Frick refrigerating machine ran during this test and furnished the tenants with ice water, for which an allowance was made. It is a 10-ton refrigerating system, and has a 7½&10½x8 in. machine, operated by a Corliss engine under a reduced steam pressure of 80 lb. The back pressure on the compressors was 15 lb. and the condenser pressure 150 lb., the speed of the machine being maintained at 95 r.p.m. The city water is taken at a temperature of 75 deg. and cooled to an average of 44 deg. at the fountains throughout the building, of which there are 50 between the basement and the 28th floor. From the test 468 lb. of steam was used by the ice machine per hour, or 3,744 lb. during the 8-hr. test, which required 430 lb. of coal at a cost of 47c.

To pump the water to the tanks upon the 18th and 30th floors there are two Fairbanks-Morse house pumps, size 12&18x7x12 in. Only one is in service at a time, the other being kept for auxiliary service and the two are used alternately day by day. An average of 680 cu.ft. of water was pumped from the engine-room service tank per hour, to the tank on the 30th floor, which is about 434 ft. above the floor of the engine room. The steam required per hour to pump the water was 461 lb., or 1.47 cu.ft. of water pumped with 1 lb. of steam. The 8-hr. test indicated that $0.477 in fuel was consumed to maintain and operate the house pump. To pump 1,000 gal. of water it took 90.7 lb. of steam and 9.96 lb. of coal, making the cost of coal $0.010906.

The foregoing tests indicate that the engineering crew of the plant have the conditions thoroughly in hand, and also show the economic conditions that are maintained.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—Hunter tells about some of the causes for air-compressor explosions and what to do to prevent them. He also tells about pipe-line volumes and the advantages of long-stroke compressors.

One evening, while reading the newspaper I came to an item regarding an air-compressor explosion. Having finished the article, I handed the paper to Hunter, at the same time asking what he had to say regarding such occurrences.

"I've had some experience with air compressors, had a number of accidents to them, but never was so unfortunate as to have had an explosion," answered Hunter. "A number of fatal accidents have occurred, with which I am familiar, which were caused by the machine disrupting or by the air line giving out, especially close to the compressor. I remember one accident that occurred about six years ago, caused by an explosion in a 5-in. discharge pipe of a four-stage compressor, and carrying about 950 lb. pressure. A piece about 8 in. diameter was blown out of the pipe, and all of the windows in the compressor room were smashed."

"And the compressor was wrecked, I suppose," I suggested.

"That's the best part of it; the machine wasn't damaged at all, and as soon as a new piece of pipe was put in, it was started up and ran the same as usual."

"What caused the explosion, or wasn't it ever determined?"

"Well, it wasn't positively known at the time, but it was undoubtedly caused by the excessive use of oil, probably ignited by imperfect action of the valves in the fourth-stage of the compressor."

"Isn't there any practical means of determining whether the valves are operating properly?" I asked, at the same time watching the coming to life of the "bell hops" because of the arrival of the hotel bus from the train just in.

"Certainly," answered Hunter. "A recording thermometer that will register continuously the temperature of the air at the point where it passes into the discharge pipe line will enable the engineer to detect to some

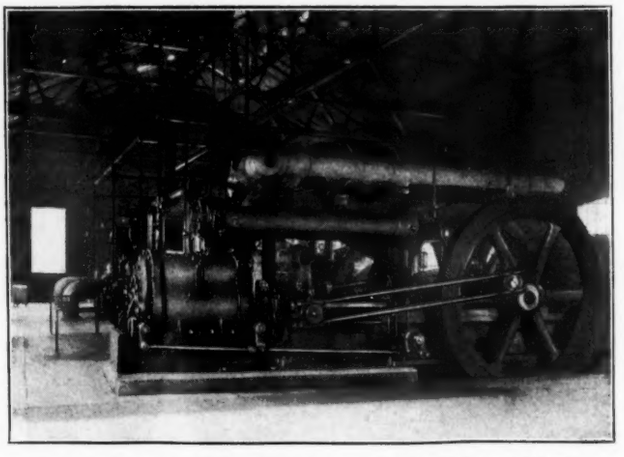


FIG. 1. AIR COMPRESSORS AT THE IRON MINE

extent any seriously defective operation of the compressor valves. You see, under normal conditions with, say 1,000 lb. pressure, the temperature of the discharge air should be about 235 to 240 and should never exceed 250 deg. F."

"Why wouldn't a fusible plug be a good safeguard?" I asked, as in my mind's eye I saw fragments of air compressors flying through the air.

"Humph!" grunted Hunter. "You are several miles behind the last man. Why, fusible plugs are used, used extensively, and they are a good thing because they give evidence of internal conditions which, if not detected, would result seriously. A small quantity of oil, say not over four gallons per month, supplemented with a solution

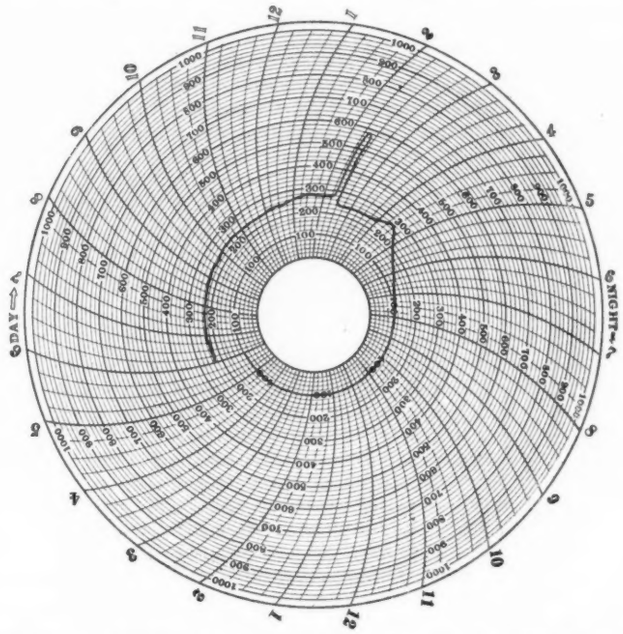


FIG. 2. TEMPERATURE CHART FOR AIR COMPRESSOR

of castile soap and water will amply lubricate the internal surfaces."

"Just how will a recording thermometer tell what is wrong with the machine and if the compressor valves are not working properly, and why does the temperature rise?" I asked.

"I'll answer the last question first. When the discharge valves are not working properly, the compressed air works back from the air line into the last stage of the compressor and this 'churning' of the air produces heat faster than the cooling water can absorb it. The thermometer records this increase of temperature, and if the engineer is onto his job he will observe any difference above the normal and attend to the matter. Come up to my room, and I will show you a chart that will explain just what I mean much more quickly than I can explain without it."

We went to Hunter's room, and he produced the chart shown in Fig. 2.

"This chart," explained he, "shows that the temperature of the compressed air at the entrance to the line was about 240 deg. from 6 a.m. until a little after 12 p.m., when the temperature began to increase until about 270 deg. was registered. Do you see that jump at 2:18 p.m.? Well, that represents the time of an internal explosion. The engineer knew the temperature was increasing, but he wanted to pull the machine through until 6 p.m. if he could, but the temperature said no. The sudden drop in temperature is due to the melting of a fusible plug, which released the pressure and reduced the temperature. The engineer tried to run the machine after the explosion, but the high temperature caused him to shut down at about 4:30 p.m. The remedy was the setting of the defective valve, after which the compressor ran with a normal temperature."

"Isn't there any way to prevent those internal explosions?" I asked as I arose to go to my own room for the night.

"Well, the occurrences would be reduced if a solution of soft soap and water were used to clean the air cylinder, and it can be used without danger. You see, in a steam cylinder there is a washing effect that is not present in an air cylinder, where the oil remains longer. For that reason a small amount of oil will lubricate an air cylinder satisfactorily. A cheap low-flash oil should never be used. If carbon and oil could be kept out of the receiver and pipes, explosions would be few and far between."

"Well, I guess that is about all for tonight," I remarked, rising to go; "and don't forget that we are to go on a scouting trip tomorrow."

"I won't," replied Hunter, who was already kicking off his shoes.

The next morning we started out early and finally found ourselves exchanging "the top of the morning" with the mine superintendent of one of the Sloss-Sheffield Steel and Iron Co.'s iron mines. Here we found a fine modern steam-turbine plant and four air compressors, Fig. 1. These compressors discharged into two receivers

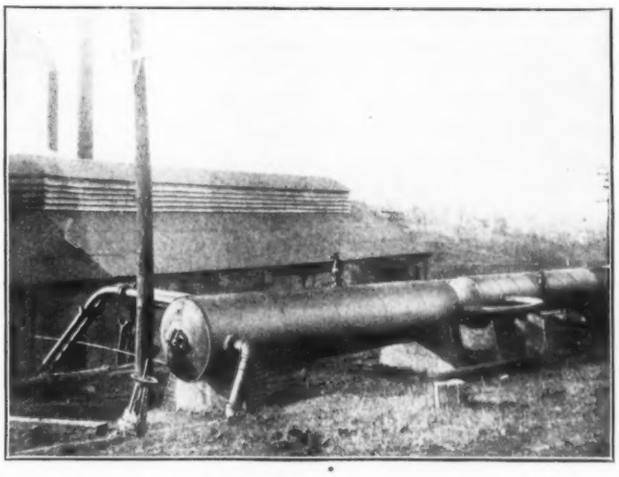


FIG. 3. ARRANGEMENT OF COMPRESSED AIR TANKS

placed on brick foundations out in the open, back of the power plant. The receivers were connected by a U-bend, and each was fitted with a safety valve, Fig. 3. From these receivers air pipes ran to the mine for use in drilling, etc.

As we examined the general layout of the apparatus, Hunter said: "The economy of air transmission depends on how much money is to be tied up in the first cost. If I remember correctly, it costs to carry a certain volume of air through a length of 1-in. pipe more than three times as much as through the same length of 2-in. pipe. Take a case of a one-pipe line where more power is required. The natural thing is to put in another pipe line to take care of the extra work, but the loss of head in the two lines would be more than the loss in a single

line having an internal area equal to the combined areas of the two pipes."

"That's worth knowing for the man who is about to increase the volume of air used and is thinking of putting in a duplicate line," said I. "However, as I see it, most air pipes run underground and are difficult and costly to get at, and most engineers would hesitate about advising the discarding of the old line for a new and larger one."

"Yest I suppose so," replied Hunter, "but if a duplicate pipe line is to be put in it would not cost so very much more to put in a single pipe of a size to carry the volume of air to be handled by the two smaller pipes. Besides the diameter, the inner surface of the pipe, the character of the joint, number of valves and bends, and other factors all contribute to the loss in head. An air line should be tight at the joints and allowance must be made for expansion and contraction, especially if it is above ground. There isn't any sense in compressing air and letting it leak out through poor joints."

We had by this time returned to the engine room. Hunter stood looking at one of the compressors.

"Do you know," said he, "that when air is compressed into a smaller volume the pressure increases directly in proportion to the decrease in volume if the temperature remains the same? If the volume is one-half, the pressure will be doubled; if one-third, it will be trebled; and so on for any decrease in volume."

Pressure and Temperature Increase

"I thought you said last night that in compressing air the temperature increased."

"So I did. There is an increase in temperature and a consequent increase in volume because of the heat developed during compression. When air is compressed, the work done during compression is converted into heat which is taken up by the air. As this increases the temperature of the air and increases its volume, it adds considerable to the work to be done. That is why means for cooling the compressed air are used. Stunts now abandoned were injecting a spray of water into the cylinder, circulating water through the piston and around the heads and cylinder. Cylinder heads and the barrels are still water-jacketed, but the other methods have been discontinued. The modern method of removing the heat of compression and of reducing the power required is to divide the compressor into two or more stages, the number being determined by the terminal pressure to be carried. The air is cooled between stages by passing it through suitable cooling apparatus. The cylinders are water-jacketed, however, so as to reduce the temperature to a point that will permit of their being properly lubricated."

"I have noticed that some compressors have a long and that others have a short stroke. What are the advantages of one over the other?"

"It's a matter of clearance, my boy," answered Hunter. "You can't run a compressor without some clearance, but the smaller it is the better. At the end of the stroke the clearance space is filled with air at the terminal pressure, and it has got to expand back to the initial pressure before the inlet valve opens. In a compressor, the longer the stroke the less percentage of clearance is required for any given volume. If a machine has a 30x60-in. air cylinder with a 1½-per cent. of clearance and the stroke was shortened to 30 in., or one-half, the percentage of clearance would be doubled, or 3 per cent. So you see that for a given capacity it is better to use a cylinder of small diameter and long stroke."

At this stage of the proceedings, Hunter pulled out his watch, and as he had an engagement for the afternoon, he suggested that he leave me to look around for myself while he went back to town. While looking around I learned something about condensers.

Small Geared Turbine-Driven Generating Units

The success of the large turbo-generator has created a demand for small turbo-units. Attempts to produce satisfactory models of the large machines in small sizes proved a failure, however, because small generators that were reliable, efficient and low in cost had to be slow-speed machines, whereas small turbines to have the same characteristics had to be high-speed machines. The solution of this problem appears to lie in the reduction gear, which permits a low-speed machine to be driven economically by a high-speed turbine. The illustrations show some Westinghouse geared turbine-driven generators, which are built in capacities of from 15 to 500 kw. for both alternating and direct current.

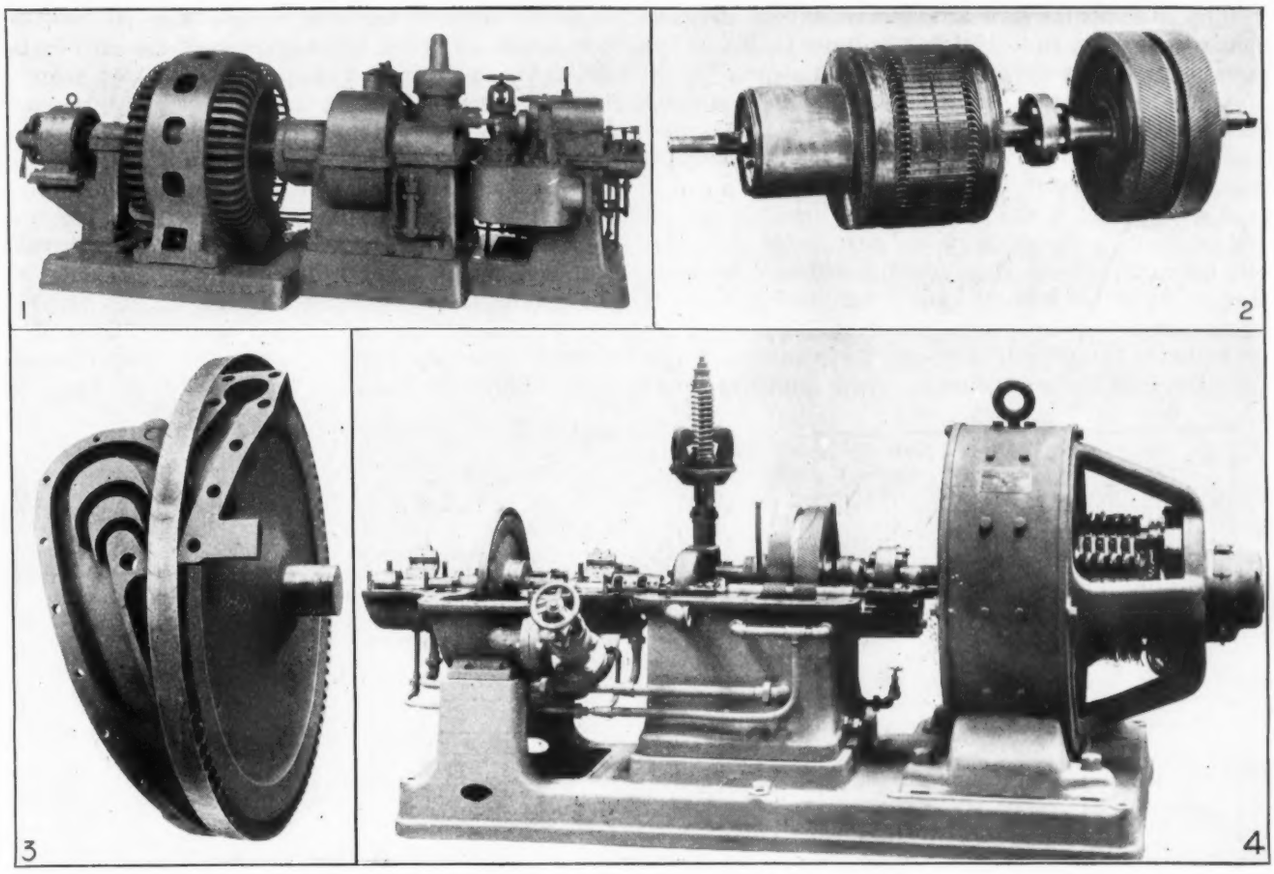
The gears are of the split helical type, with teeth of the involute form. The angle of the helix is large, so that several teeth are in contact at the same time, thus giving small individual tooth pressure and transmitting the power without shock or vibration. The efficiency of the gear is said to be over 97 per cent. For small units both the gear and the pinion are steel forgings, but in the large gears the teeth are cut in a carbon-steel ring which is shrunk on a cast-iron hub and then keyed to the latter.

Impulse Type Noncondensing Turbines

The turbines used in this line are of the impulse type and are best suited for noncondensing operation. The normal speed ranges from 6,000 to 7,200 r.p.m., depending on the size. The turbine rotor is of openhearth steel with the section tapering toward the rim, and the blades are individually inserted in a groove in the rim of the rotor and retained by steel rivets through their shanks.

Owing to the relatively high speed, it is necessary only to pass the steam through the rotor twice to utilize its available energy. The steam expands in the nozzle from inlet to exhaust pressure, acquires a high velocity and passes through the blading, where practically half of its velocity is utilized. Then it enters the reversing chamber and is redirected against the blading, thus giving up the remainder of its velocity. In order to secure high economy at all loads, two sets of nozzles and reversing chambers are used, each supplied by steam from a hand-operated valve. As ordinarily arranged, one of the nozzles provides steam for ¾ normal load operation and the two together steam for carrying the maximum or 1¼ times full load.

The spindle-packing valve is of the water-sealed type and consists of a simple paddle-wheel and its containing casing. Water at three or four pounds' gage pressure is admitted to the gland for sealing.



FIGS. 1 TO 4. SOME VIEWS OF SMALL WESTINGHOUSE TURBINE-DRIVEN UNITS

Fig. 1—300-kw. alternating-current set. Fig. 2—Armature and gear typical of all sizes. Fig. 3—Nozzle block and reversing chamber with rotor. Fig. 4—100-kw. direct-current unit with covers removed

The gear case serves as an oil reservoir. In the large units the oil is distributed to the bearings and governor by a pump; in the small units, the gear dips into the oil and throws a copious supply against the gear cover, where it is caught in pockets and flows by gravity to the bearings; thence back to the reservoir. The oil is kept at the proper temperature by cooling coils in the bottom of the reservoir through which water flows.

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Fundamental Principles of Alternating Current—V

By F. A. Annett

SYNOPSIS—The two-phase circuit explained and the resultant e.m.f. and current in a two-phase three-wire system is derived.

The alternating-current circuits dealt with in the preceding articles were single-phase. So long as alternating current was used only for lighting purposes, the single-phase system gave complete satisfaction. With its advent into the power field, however, the difficulty arose of making the single-phase motor self-starting without employing some auxiliary starting device at the expense of ruggedness and simplicity of construction.

Ferarris in 1888 discovered that a rotating magnetic field could be produced by two or more alternating currents displaced in phase from one another. This led to the development of the polyphase systems.

Instead of revolving one conductor about an axis in a magnetic field, as in Figs. 7 and 8 (Part 1, issue of Dec. 7), let two conductors be arranged 90 deg. apart, as in Fig. 44. It is obvious in this arrangement that when conductor *A* is on the vertical axis generating a maximum e.m.f., conductor *B* will be on the horizontal, or neutral axis and its e.m.f. will be zero. As the conductors move in the circular path as indicated, the e.m.f. generated in *A* will decrease and that in *B* increase until they are in the position shown in Fig. 45, where the voltage in *A* will be zero, while that in *B* will be a maximum. From this it is seen that the e.m.f.'s generated in *A* and *B* will pass through the same series of values, but when one is at a maximum the other will be at zero. Curves *A* and *B*, Fig. 46, show the relation between the two e.m.f.'s, which are said to be 90 electrical degrees apart. To produce this combination of e.m.f.'s the conductors will be 90 space degrees apart only on a two-pole machine; on a four-pole machine they will be 45 space degrees apart, as in Fig. 47; on a six-pole machine 30 deg. apart; and on an eight-pole machine 22.5 deg. apart.

Fig. 48 shows the same arrangement of coils and polepieces as in Figs. 16 to 19 (Part 2, Dec. 21), but in this case four collector rings are used instead of two. If the four rings are connected to the winding at equidistant points around the armature (in this case 90 deg.), when the armature is in the position indicated a maximum e.m.f. will be generated between collector rings a and a' and zero between b and b'. When the armature has revolved through 90 deg. to the position indicated in Fig. 49, the e.m.f. between rings a and a' will have decreased to zero, while that between b and b' will have increased to a maximum.

From the foregoing it is evident that two e.m.f.'s may be taken from the same winding, which are 90 electrical degrees apart. This is the same as was generated by the two conductors, Figs. 44 and 45; therefore curves A and B, Fig. 46, show the relation between the e.m.f.'s taken from collector rings in Figs. 48 and 49.

In practice, instead of using a ring armature with one winding as in Figs. 48 and 49, two windings are used similar to the arrangement shown diagrammatically in Fig. 50, which represents a four-pole two-phase alternator. In this winding there are 12 coils per circuit, or as it is usually termed, 12 coils per phase. One phase of the winding is represented by dotted lines and the other by full lines. At the instant shown in the figure, the winding of phase A is under the polepieces and will therefore be generating a maximum e.m.f., while that of phase B is between the polepieces, consequently the e.m.f. in it will be zero; hence the e.m.f.'s generated by these two windings will be the same as those generated by the ring armature, Figs. 48 and 49.

For simplicity the conventional diagram of Fig. 51 may be used to represent the two phases, indicating that the two windings are displaced 90 electrical or time degrees on the armature. A more convenient way is shown in Fig. 52, especially where the windings are grouped.

So far only the four-wire two-phase system has been considered. When a winding is used for each phase, as in Fig. 50, they may be connected in series and a common terminal brought out, as in Fig. 53, which is known as a three-wire two-phase system. This would be impossible with only one winding, for if any two of the rings were together it would short-circuit the winding.

Since the e.m.f.'s of the two phases are out of step by 90 deg., the voltage between the two outside terminals, Fig. 53, will not be their arithmetical sum but the resultant, as explained in Part 4, Feb. 1, Fig. 54, is a simple vector diagram showing the relation between the two e.m.f.'s of a two-phase circuit.

By adding the two e.m.f.'s vectorially, the parallelogram $OACB$ (Fig. 55) is formed, the diagonal OC being the resultant of the two voltages and representing to scale the pressure between the two outside terminals in Fig. 53. In this case since the two e.m.f.'s are equal, the parallelogram will be a square, and the diagonal of a square equals one side multiplied by $\sqrt{2}$. If it is assumed that the effective e.m.f. of each phase is 135 volts, the pressure between the two outside terminals will be $135 \times 1.414 = 191$ volts approximately.

The same relation holds with the current; that is $I' = I\sqrt{2}$, where I' is the current in the middle wire and I that in either outside leg, where the current of each phase is the same. Assume the current per phase, Fig. 53, to be 35 amp., the current in the middle wire is $I' = I\sqrt{2} = 35 \times 1.414 = 49.5$ amp.

The foregoing statements may be verified by combining the two curves in Fig. 46, as indicated by the dotted curve, which is obtained by adding algebraically the instantaneous values on the curve of each phase. The maximum of this resultant curve is 1.414 times that of A or B; furthermore, the dotted curve is displaced from A and B, being 45 deg. behind A and 45 deg. ahead of B.

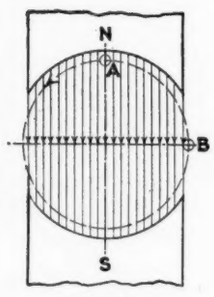


FIG. 44

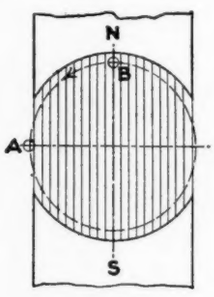


FIG. 45

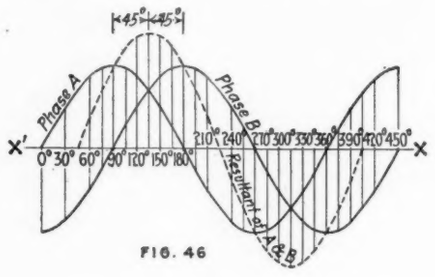


FIG. 46

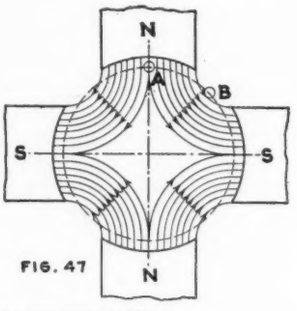


FIG. 47

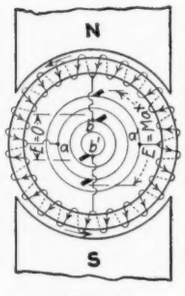


FIG. 48

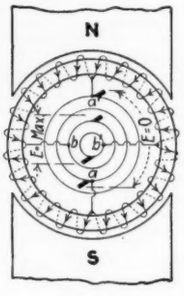


FIG. 49

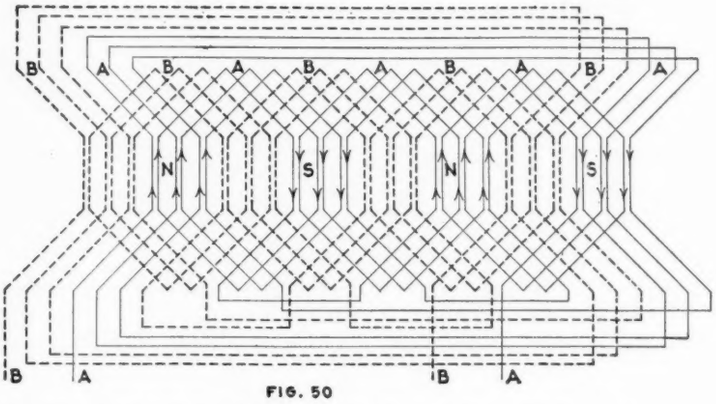


FIG. 50

FIGS. 44 TO 50. ILLUSTRATING THE GENERATION OF TWO-PHASE CURRENTS IN A MACHINE

Since the current in the center wire of a balanced three-wire two-phase circuit is 1.414 times that carried by either of the outside wires, the copper in the center conductor will have to be 1.414 that of one of the outside conductors. From this it is evident that the saving in copper in the three-wire system over that of a four-wire is not as great as might be expected; that is, the copper in the former is 85 per cent. of that in the latter.

The expressions $E' = E\sqrt{2}$, and $I' = I\sqrt{2}$ hold true only where the e.m.f. across, or the current in, each phase is the same. In Fig. 55 if the voltage of phase A be represented by E_1, that of phase B by E_2 and the voltage between the two outside legs by E', then $E' = \sqrt{E_1^2 + E_2^2}$, which can be used where the voltages of the two phases are not equal. To find the current in the center leg where the current in the two phases differ in value, the foregoing may be changed to $I' = \sqrt{I_1^2 + I_2^2}$, where I' is the current in the middle wire and I_1 and I_2 that in phases A and B respectively.

Assuming that in the three-wire two-phase circuit, Fig. 56, the voltage of phase A is 235 and that of phase B 175 volts, and the current in phase A 56 amp. and in phase B 43 amp., let it be required to find (1) the e.m.f. between the two outside terminals and (2) the current in the center leg of the circuit.

$$E' = \sqrt{E_1^2 + E_2^2} = \sqrt{235^2 + 175^2} = 271 \text{ volts} \quad (1)$$

$$I' = \sqrt{I_1^2 + I_2^2} = \sqrt{56^2 + 43^2} = 70.6 \text{ amp.} \quad (2)$$

Figs. 57 and 58 are vector diagrams of the voltage and current respectively of Fig. 56.

In practice the e.m.f.'s are seldom very much out of balance on a two-phase system. Where a lighting system is supplied from a two-phase circuit, the current can be almost any value in the two phases, depending on how the load is distributed, although efforts are usually made to keep it as nearly balanced as possible.

To summarize: In practice a two-phase generator is one that has two armature windings in it so placed that when one is generating a maximum e.m.f., the e.m.f. in the other is at zero. When the four terminals of the two windings are brought out to a four-wire circuit, the combination is called a four-wire two-phase system. This scheme is practically the same as two single-phase systems combined in one, but it has the advantage that the currents in the two phases are displaced 90 deg., thus making it possible for a motor designed for this system to be self-starting without any auxiliary starting device.

The two armature windings may be connected in series and a common wire brought out from the junction, thus doing away with one of the four wires. The machine may then be used to supply energy to a three-wire circuit. In a three-wire two-phase circuit where the voltage on each phase is the same (which is always the case in practice) the e.m.f. across the two outside terminals equals that of one phase multiplied by 1.414. This relation holds true also for the current, where the current in each phase is the same. The value just given for the current in the center wire is the maximum that it will have to transmit under almost any condition, therefore the current in the center wire for an unbalanced load is not of so much importance, but can be found by taking the square root of the sum of the squares of the current in amperes in each phase.

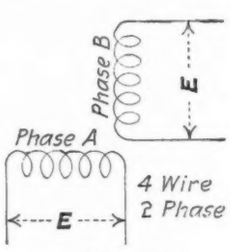


FIG. 51

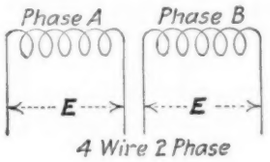


FIG. 52

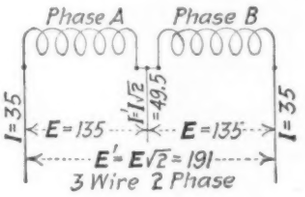


FIG. 53

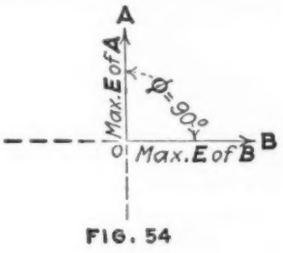


FIG. 54

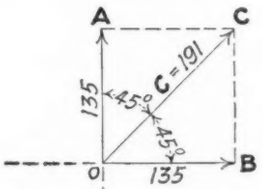


FIG. 55

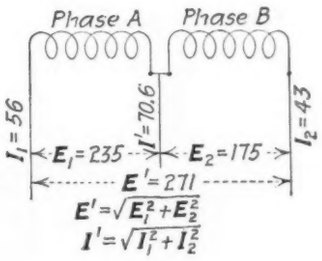


FIG. 56

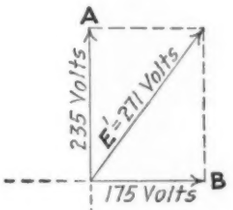


FIG. 57

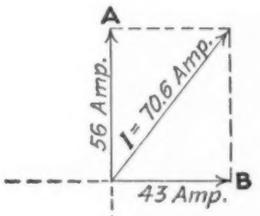


FIG. 58

FIGS. 51 TO 58. TWO-PHASE CIRCUIT REPRESENTED DIAGRAMMATICALLY AND VECTORIALLY

Power Costs on Street Railways

An investigation of the cost of power for the fiscal year 1914 on the twenty-five larger street railways of Massachusetts is a feature of the third annual report of the Public Service Commission of that state. The analysis was made by Prof. Lewis E. Moore, of the commission's engineering department, and shows that the cost of direct current per kilowatt-hour ranged from 0.58c. on the Boston Elevated Ry. to 2.85c. on the Massachusetts Northern Street Ry., exclusive of fixed charges. Taking fixed charges into account and allowing 11 per cent. for interest and depreciation, the cost ranged from 1.28c. on the former to 3.65c. on the latter, although a water-power plant of the Fitchburg & Leominster Street Ry. produced energy at 0.82c., including these charges. Fourteen of the companies purchase energy at prices ranging from 0.45c. per kw.hr. at Worcester, to 2.82c. on the Blue Hill Street Ry. Only one of the fourteen companies buys all its power. Interest on stand-by plants was not included in the tabulation.

The importance of the power problem to the Boston Elevated and the Bay State Street Ry.—the two largest companies—is indicated by the fact that the former required 212,916,787 kw.-hr. of direct current for the operation of its 59,199,607 car-miles in the year, and the latter 104,231,942 kw.-hr. for 30,612,321 car-miles. For fuel the Boston Elevated expended $858,415 and the Bay State company $568,270, the average prices of coal per ton being $3.56 for the former and $4 for the latter.

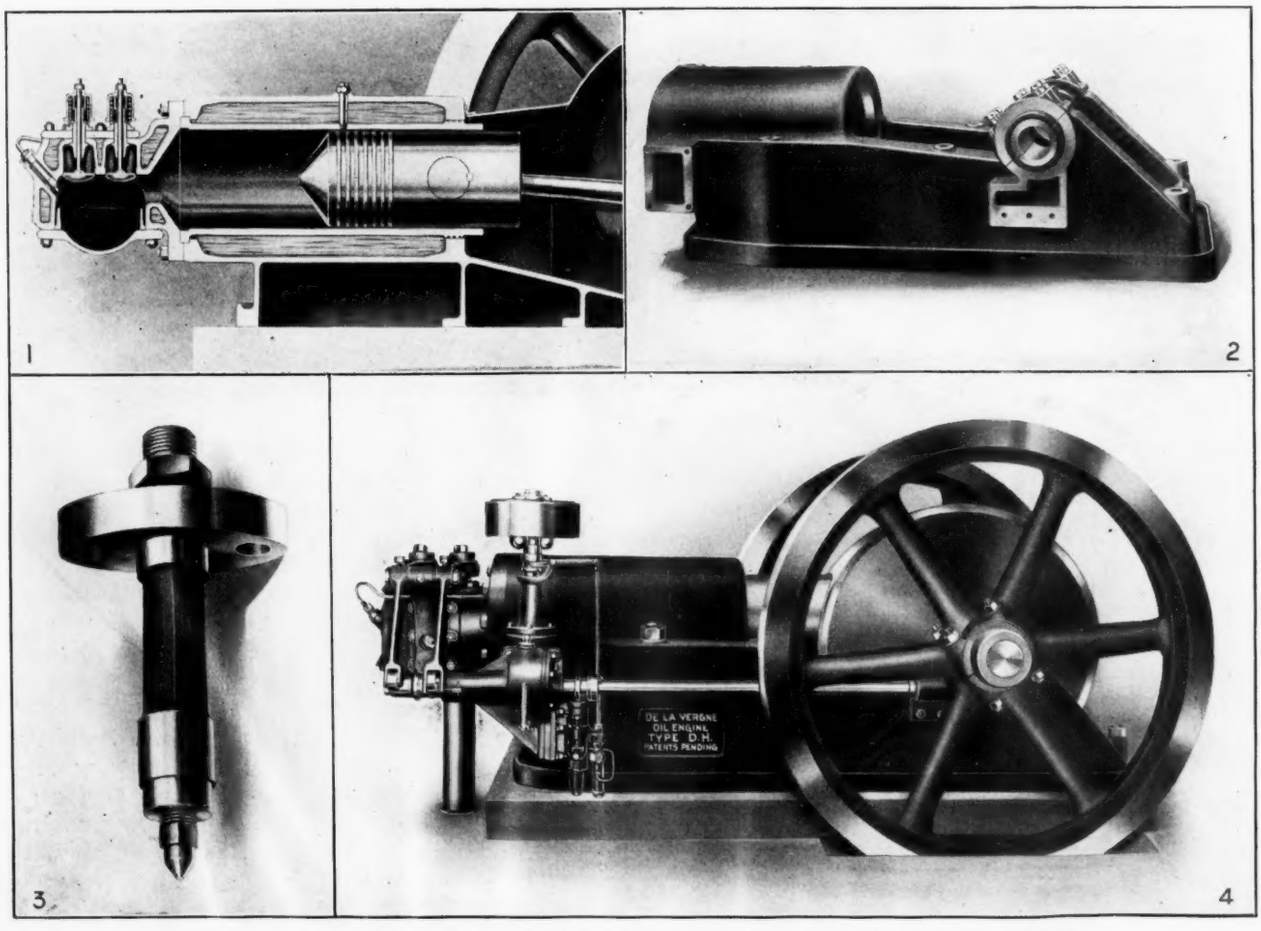
Low-Compression De La Vergne Type "DH" Oil Engine

A low-compression oil engine operating on the four-stroke cycle and designated as type "DH" has recently been put out by the De La Vergne Machine Co. Built in sizes of 40, 60 and 100 hp. per cylinder in the single and twin-cylinder types, this engine has been designed with the view to simplicity in construction and operation, at a slight sacrifice in economy; it being figured that the saving in first cost, maintenance and labor thereby effected in an engine of this size will more than offset the small increase in fuel consumption.

The guaranteed fuel consumption ranges from 0.55 lb. per b.hp.-hr. at full load to 0.65 lb. at half-load, with any commercial crude oil, distillate or fuel oil having a lower heat value of not less than 18,000 B.t.u. per lb and containing not over 1 per cent. water. Although the engine is said to be able to burn any grade of oil successfully, it is understood that the necessity for preheating a very viscous oil and the additional labor involved make it generally undesirable to use an oil heavier than 18 deg. Bé.

Perhaps the most important simplification has been the substitution of mechanical for air injection of the fuel, thus eliminating the air compressor with its attendant supervision. A comparatively simple cylinder head is employed, and the lower pressures—150 lb. compression and 300 lb. ignition pressure—have made possible a somewhat lighter frame. A general view of the assembled engine is shown in Fig. 4, and Fig. 1 is a longitudinal section through the cylinder. From this it will be seen that a vaporizing chamber is employed to vaporize and ignite the oil. The bottom of this vaporizer, which is unjacketed and upon which the oil impinges, must of course be heated in starting, an operation said to require only about two minutes with the improved torch now in use. After the engine is running, the plate is kept hot by the heat of the explosions. It may be easily removed for inspection of the vaporizing chamber, and with the plate off the air and exhaust valves may be taken out from the bottom. A center-crank type of construction is employed, with the two flywheels in the single-cylinder unit; and the two-cylinder unit, except for the flywheels, is essentially two single-cylinder units bolted together with separate camshafts and independent fuel pumps controlled by one governor.

The cylinder is cast integral with the frame and contains a removable liner of hard gray iron. This is held at one end by a shoulder between the cylinder and the head, the other end being free to expand. The piston, which is 12½ in. dia. in the 40-hp. size, 14 in. in the 60-



FIGS. 1 TO 4. VIEWS OF DE LA VERGNE TYPE "DH" LOW-COMPRESSION OIL ENGINE

hp. size, and 19 in. in the 100-hp. size, is unusually long and carries 7 rings at the head end, there being none at the crank end, as it has been found that there is little tendency for the cylinder oil to squeeze out into the crank case in a horizontal engine of this type. No crosshead is employed, and the ratio of connecting-rod length to stroke is about 5.5 to 1.

The air is drawn in through an opening in the top of the crank case and passes through a cored passage in the frame and a short connection to the inlet valve. A deflecting shield is so placed under this opening in the crank case that any vapors that may leak past the piston are drawn with the fresh air into the cylinder and do not get out into the engine room.

The fuel pump, mounted at the side of the frame below the governor, is operated by the camshaft, which is driven through a bevel gear from the main shaft. The governor controls a bypass from the discharge of the pump, and thus regulates the amount of fuel to suit the load.

As previously mentioned, on the twin engine each cylinder has its own fuel pump with the governor acting jointly on both bypasses. Adjustment is here provided to equalize the fuel supply to the two cylinders, also hand adjustment is provided on the cam to alter the time of fuel injection, which is ordinarily fixed at 25 deg. early for the opening of the fuel valve, and 15 deg. past center for the closing. The engine is said to be capable of carrying a 10 per cent. overload for 2 hr., and the guaranteed speed regulation is 4 per cent. from no load to full load, and 2 per cent. within the ordinary range of load. The fuel valve is shown in Fig. 3.

The bearings and cylinder are lubricated by a forced-feed lubricator driven from the camshaft, and the crankpin by a centrifugal oiler. A hole is bored longitudinally through the connecting-rod, and some of this oil from the crankpin is forced to the wristpin by the inertia of the rod. The engine is said to require about 1½ gal. of lubricating oil per 1,000 rated hp.-hr. and 5 gal. of cooling water with an inlet temperature of 70 deg. F. and an outlet temperature of 160 deg.

In the larger sizes the engine is started by compressed air from starting tanks, and a small gasoline-engine driven compressor is furnished for replacing the air in these tanks. In the 40-hp. size, however, a small pipe containing a check valve leads from the working cylinder to the starting tank, and pressure is here built up from that in the working cylinder. A valve in this line permits the supply to be shut off when the desired pressure in the tank has been reached.

The weight of the engine averages about 400 lb. per hp.

Cost of Steam—The following results of tests to determine the cost per 1,000 lb. of steam with different coals are given by the New York Service Co.:

Grade of Coal	Market Price Net Ton	Cost of Generating 1,000 Lb. Steam Test No. 1	Test No. 2
Soft and No. 3 buckwheat.	$2.50	12.61c.	12.26c.
No. 3 buckwheat.....	3.15	15.6	16.4
No. 2 buckwheat.....	3.15	19.0	19.6
No. 1 buckwheat.....	3.65	19.86	18.25
Pea	4.25	21.7	20.0

The Annual Report of the Supervising Inspector General of the Steamboat Inspection Service for the fiscal year ended June 30, 1915, sets forth that during that time there were inspected 11,554 boilers, of which 271 gave away under hydrostatic pressure, while 1,309 showed defects from other causes and in other ways. The total number of defects reported was 25,206; 75 boilers were condemned from further use, and there was a property loss of $95,378 due to boiler explosions or to the accidental escape of steam.

JUST FOR FUN

Wise in His Own Conceit

A grocery clerk, employed to help the fireman, after about three months remarked: "I've got this firing game down pat, and there's nothing to it."

A few days later the regular fireman did not show up, and the care of the boiler-room outfit was "up to him." At 7:15 he excitedly reported, "The water's low and the pump won't start." He was told to start the injector, but after trying a while, reported that it would not work. Then he was told to open the feed valves to the boilers and give things a chance.

Just then a gage-glass broke with a bang and a shriek of the column whistle. He was told to shut it off, but did not know how and was afraid of being scalded. After the engineer had shut off the glass, Mr. Clerk was told to use the gage-cocks. In a little while water was coming out of the water-column safety whistle. He had mistaken the white spray from the gage-cocks for steam instead of water and was filling the boilers accordingly. Now he knows that he don't know the firing game.—Charles Haeusser, Albany, N. Y.

Boilers Required More Water

Jones was chief engineer of a plant that was running four 200-hp. boilers when he came on the job. Soon after his arrival he got busy with his Orsat apparatus and ordered one boiler cut out. Mike, the fireman, did not take to the new order of things, nevertheless he bided his time.

There was no means of weighing the coal, but there was a water meter on the feed line. Several days later Mike complained to Jones as follows: "Ye ordered me to cut out wan biler, and I've been watching that meter ever since. We've using too much wather, and we ought to fire that other biler. Bedad it takes more wather with tree bilers than it did wid thim four."—J. Bailey, Milwaukee, Wis.

Engineer Was Taught a Lesson

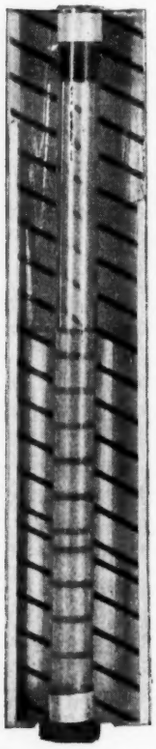
A bibulous fireman-engineer in charge of a small steam plant on the night shift was often alone for hours at a time. Coming to the job drunk one night, he fell into the wheelpit while the engine was running and was dragged along the bottom of the belt passage until his body caught on some obstruction that held him there, with the belt scrubbing his back, until steam went down, when the engine stopped and someone came to investigate. Commenting on the experience, he said: "That taught me a big lesson; nowadays I never go near an engine when I'm drunk."—H. B. McDermid, Worcester, Mass.

Exceedingly Strange

Last summer we had a low-pressure heating boiler out of service and had the boiler makers come and put in a lot of new flues. When they undertook to put a 140-lb. hydrostatic test on the boiler, the safety valve with the ball at the end of the levers lifted at 90 lb.—it was designed to do so—but they reported to the office that the safety valve leaked and should be ground in.—Willis W. Nelson, Spokane, Wash.

Water Level Indicator

"Ascertain the water level." That is the answer to the first question, namely, "What would you first do on arriving at the plant for duty?" asked of the applicant for a fireman's or an engineer's license. All too often it is difficult to tell whether there is no water in the glass or whether it is full; this is true even of the man of long power plant experience.



WATER LEVEL INDICATOR

To assist the attendant in both of these observations is the purpose of the water level indicator shown. It was invented by and is now manufactured and sold by F. Wines, 1031 Sewall St., Asbury Park, N. J. The indicator is adjustable to fit boiler-gage glasses of any size; the lines are black on a white background, and the whole is enameled. The price is 50c. apiece. Owing to refraction the water causes the diagonal lines to appear horizontal; above the level of course the lines show diagonal. The inventor says the idea came to him by accident. To produce a clear background for a dirty glass he used the side of a fancy pasteboard box with lines diagonal much the same as those used on the indicator. To his surprise the lines appeared horizontal below the water level. The indicator is attached to gage glasses of standard sizes by spring clips, facilitating removal and attachment. It is peculiar that the black lines seem to show better in a dull light than in a bright light, which of course will be found desirable. There are boilers where the device would help locate the water level.

Auxiliary Bearing on Center Crank Steam Engine

Difficulty was had with a 12x20-in. 80-hp. center-crank engine, caused by the crankshaft breaking outside of the bearing. As the bearings seemingly had insufficient bearing surface, it was decided that the shaft was subjected to a bending strain between the bearing and the belt wheel, which was set out from the former, as in Fig. 1.

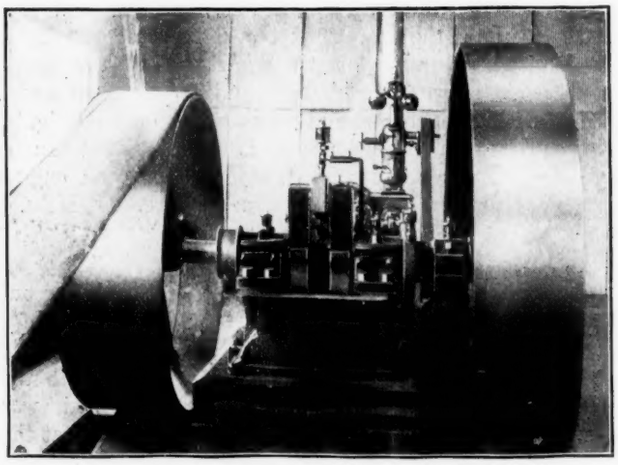


FIG. 1. END VIEW, SHOWING AUXILIARY BEARING

The last time a new crankshaft broke, it was decided to put in an auxiliary bearing. The engine bed is of brick, and an A-frame bearing casting was secured to the foundation by four ¾-in. bolts which pass through the

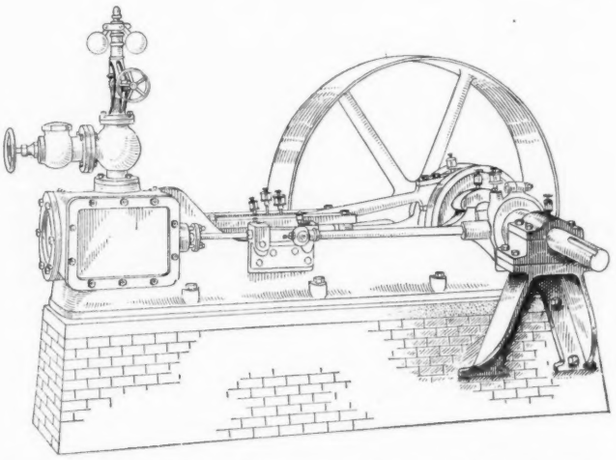


FIG. 2. AUXILIARY BEARING BOLTED TO FOUNDATION

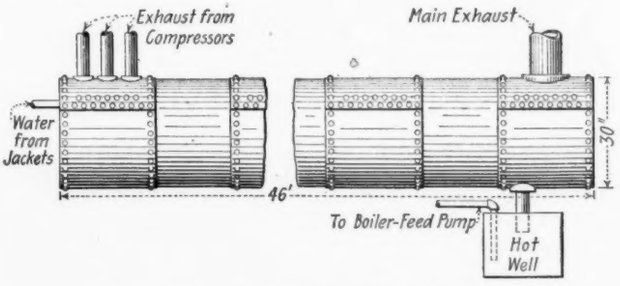
brickwork. The manner of securing the bearing is shown in Fig. 2.

Since putting on the auxiliary bearing no trouble has been experienced with breaking shafts. The engine is between 25 and 30 years old, the exact date of its make not being known. It was doubtless designed for slower speeds and lower steam pressures than its present ones.

Jacket Water for Boiler Feed

Water suitable for boiler feed is not always plentiful about a mine power plant, although there is always a large volume of mine water that is pumped to the surface. This is almost always contaminated with acids and is therefore unfit for boiler feeding or for jacketing water.

If water is purchased for use about the power plant the cost of producing a ton of coal is increased in proportion,



SHELL BOILER USED AS HEATER

and it is therefore a matter of economy to economize on the water consumption wherever possible.

At one mine in the hard-coal region an old shell boiler was brought into use. It was 30 in. dia. and 46 ft. long. At one end the exhaust pipes from several air compressors connected with the boiler; the main exhaust pipe was connected to the other end. The water to be heated came from the jackets of the compressors and entering at one end discharged at the other into a hotwell, the supply of which was controlled by a float which operated a valve in the pipe between the boiler and the hotwell. From the latter the water was pumped to the main boilers.

Remodeling a Boiler Plant Increases Efficiency

SYNOPSIS—Changes made in a boiler plant result in better operating efficiencies, and the operating force is decreased, although the boiler capacity has been increased by 800 hp.

The installation of a coal-conveying system may play an important part in the economical operation of a boiler plant. This has been found true at the plant of the H. F. Watson Co., Erie, Penn., where the operating efficiency has been increased and the boiler-room forces decreased by the installation of a coal- and ash-conveying system.

The new boiler plant consists of two 400-, two 450- and four 350-hp. water-tube boilers, a total of 3,100 boiler horsepower. To operate the old hand-fired boiler plant, which was of 2,300-hp. capacity in nine boilers, 32 men were employed, 16 on each 12-hr. shift. The daily coal consumption ran about 125 tons. The new plant requires three firemen per watch, and a coal man and a boiler washer additional on the day shift. The coal consumption is between 90 and 100 tons per day.

The reduction in labor is the result of the use of mechanical stokers and a coal-conveying system.

The present boiler plant, Fig. 1, occupies what was an old warehouse. It is about 122 ft. long by 58 ft. wide. The building has been reconstructed, the walls being extended in height, a steel roof supplanting the old one, and a 600-ton concrete-lined suspended coal bunker, supported by the roof trusses, has been installed. Coal from the bunker passes to the stoker hoppers through chute feeders.

The Stephens-Adamson coal- and ash-handling equipment that has been put in consists of a track-hopper

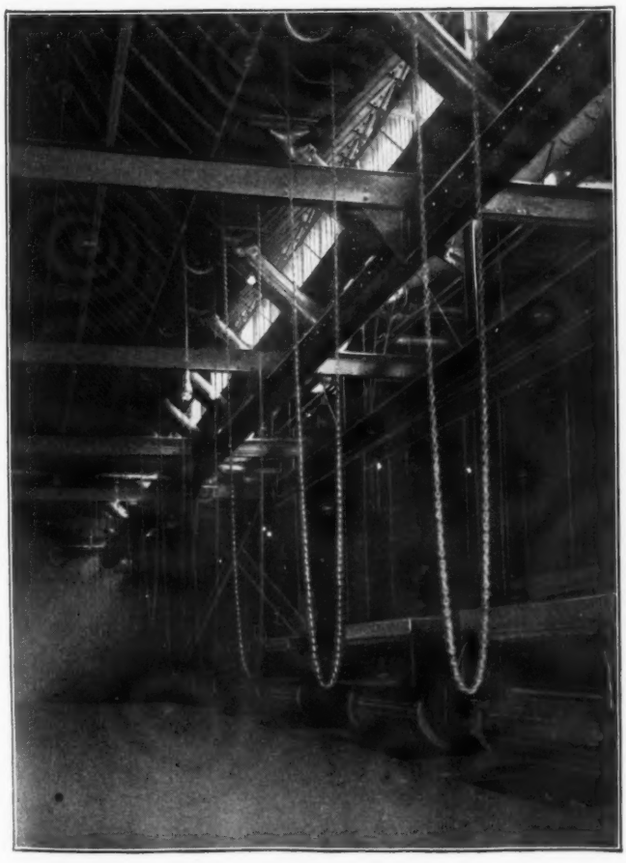


FIG. 1. BOILER ROOM AND OVERHEAD COAL BUNKER

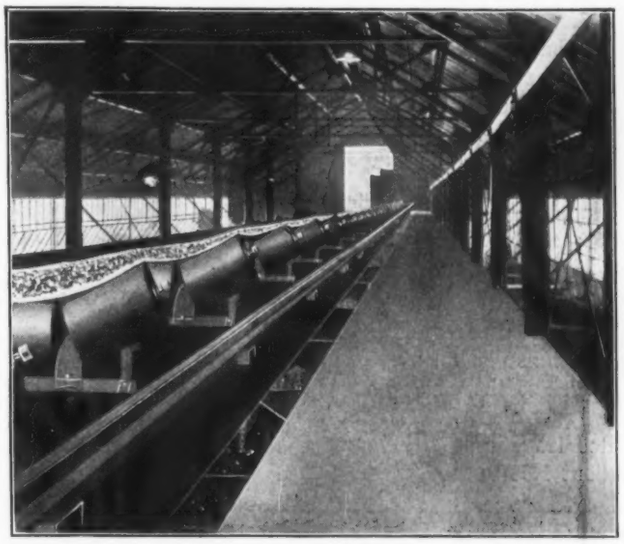


FIG. 3. BELT CONVEYOR ABOVE COAL BUNKER

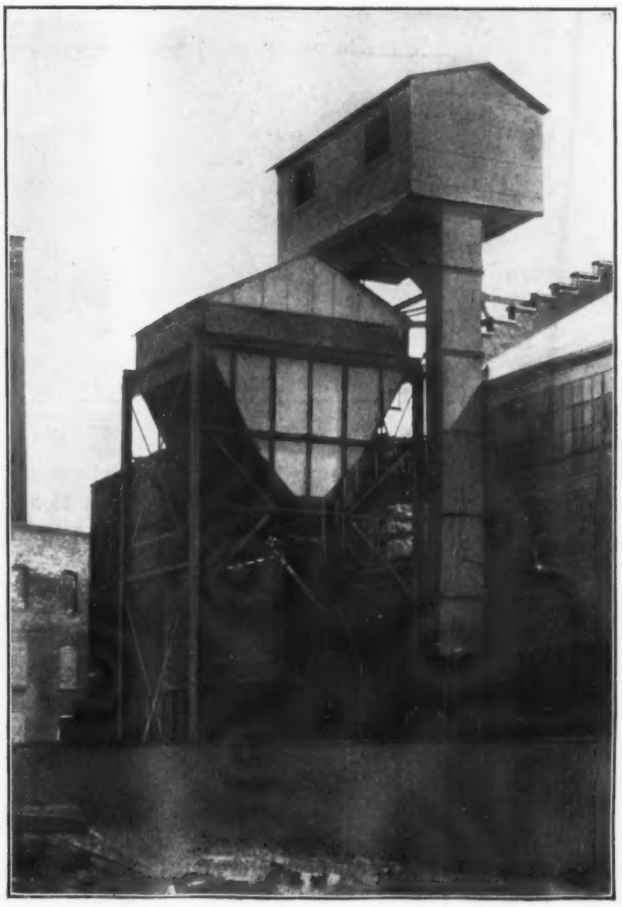


FIG. 2. COAL HOIST AND ASH BIN OUTSIDE BUILDING

crusher, a bucket and a belt conveyor. The steel track hopper, which receives coal from railway cars, is 12x12 ft. and is fitted with a reciprocating plate feeder which draws out from the hopper, and if slack coal is received the fuel is delivered direct to the bucket conveyor. When lump coal is used it is delivered to a 24x24-in. double-roll spring-release crusher, which discharges to the 24x18-in. bucket carrier, from which it is discharged into a suspended combined coal and ash bunker on the outside of the boiler house, Fig. 2. From here the coal is carried through a chute to a belt conveyor and is distributed to various parts of the coal bunker.

The belt conveyor, Fig. 3, is 18 in. wide and has 124-ft. centers. It is equipped with an automatic self-propelling tripper. The capacity of the system is 40 tons per hour. All coal delivered to the stoker is weighed and recorded. Two hand-operated traveling weigh hoppers of about 1,000 tons' capacity, traveling on rails beneath the main storage bin, at present receive from any part of the bunkers and deliver to any stoker. Plans have been formulated, however, to provide each stoker hopper with a spout connecting to the bunker at a point central to each boiler.

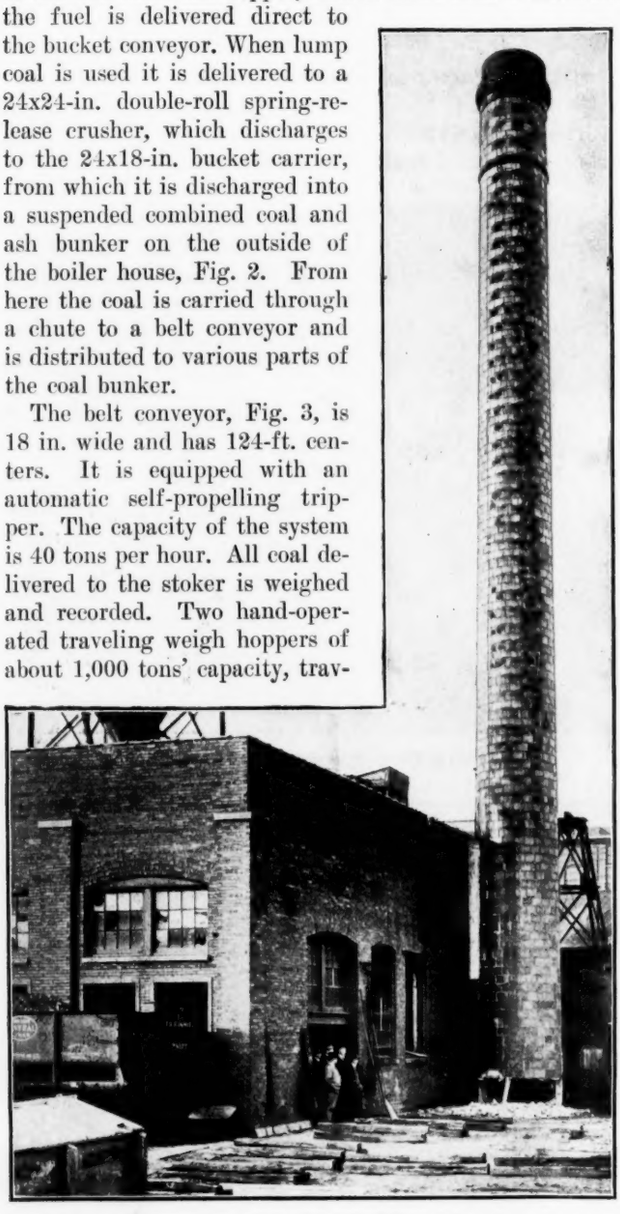


FIG. 1. THE CHIMNEY PARTLY SUPPORTED BY PROP

The same bucket carrier handles the ashes, which are discharged from the ashpits into a 27-cu.ft. capacity industrial dump ash car, from which they are dumped into a hopper and fed to the bucket conveyor, which elevates them to a discharge hopper above the outside elevated ash bunker. This hopper is fitted with a double-branch outlet, one for the discharge of coal to the belt conveyor, the other to the ash bunker. The switching of material to either spout is effected by a swing gate in the joint of the discharge pipes. The carrier will handle ashes at a rate of about 20 tons per hour, which is faster than they can be delivered to the conveyor by the ash cars.

The furnace gases go to a 227-ft. chimney of 10-ft. diameter at the top. Steam at 175 lb. pressure is supplied to various engines throughout the works aggregating 3,500 hp. Water is taken from Lake Erie and is handled by a two-million gallon pump to a tank at the works. The tank supplies the boiler-feed pump as well as the works. The pumps are also connected to the city water-supply. The boiler feed is handled by two 18& 8½x24-in. pumps, and it is heated by passing through a 3,500-hp. open heater. These units are in a room at the rear of the boiler house.

Felling a Combined Tile and Concrete Chimney

By Frank C. Perkins

The illustrations, Figs. 1, 2 and 3, show the method used in felling a combined tile and concrete chimney at Chicago, Ill. The pictures show how the stack, which was in restricted quarters, was made to fall within the desired space. It is said that this was one of the first combined tile and reinforced-concrete chimneys to be destroyed. It was situated at Thirty-first St. and Kenzie Ave. It belonged to the Liquid Carbonic Co. and was erected four years ago by the Wiederholt Construction Co. The expansion of the plant demanded a larger chimney farther from the existing building to permit of extension. On account of the restricted quarters, the owners wished to fell the chimney across three switch tracks within a limited space, at the outer, or top, end. This result was accomplished, the chimney falling within 12 in. of the desired position, by Peter Drolshagen, a chimney expert.

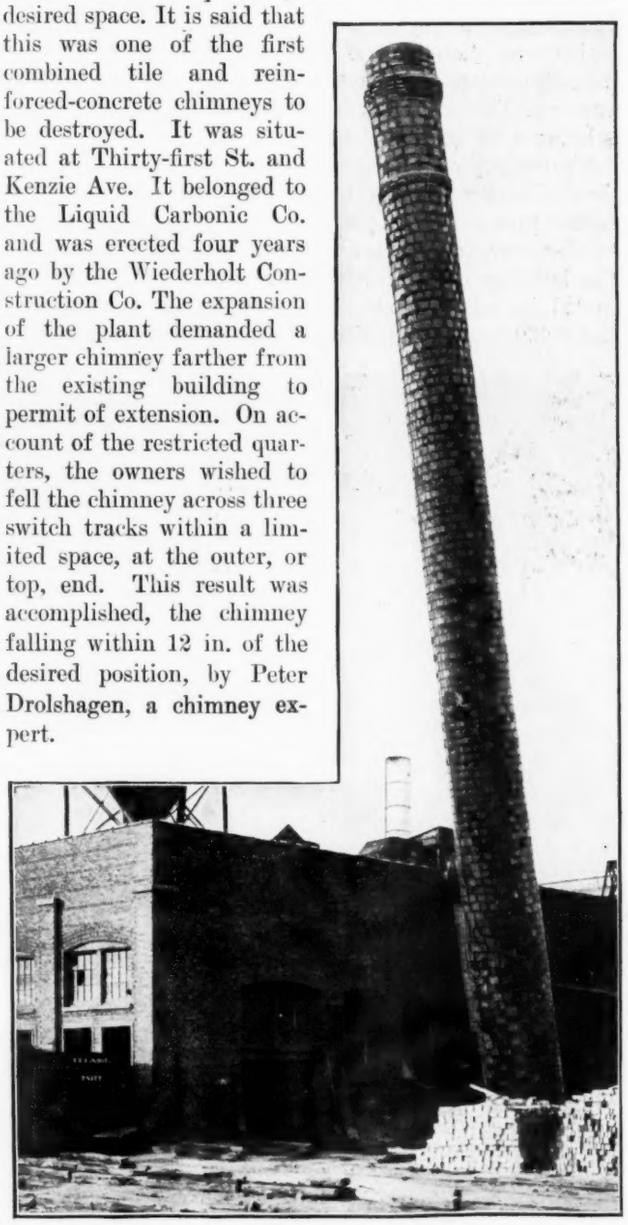


FIG. 2. THE CHIMNEY UNSUPPORTED BY PROP

It is of interest to note that in preparing for the fall four rows of 9-in. tile with the concrete at the ground level were cut away for slightly more than half the diameter of the stack. Fourteen of the reinforcing bars were cleaned of the cement, slightly nicked with a chisel and then burned off with an oxyacetylene torch. The chimney was started by striking with a sledge hammer the middle tiles at the ends of the cut.

It is said that in falling the stack rotated about the center line at the top of the cut, crushing one tile and the concrete back of it on each side. At the time the crushing was heard, cracks in a diagonal direction upward and backward appeared. The back of the chimney parted on this line about six feet from the base. The

FIG. 3. THE CHIMNEY AFTER ITS FALL WITHIN 12 IN. OF THE CALCULATED SPACE

1⅜-in. vertical reinforcing bars, which extended into the base and up into the chimney for about eight feet above the ground level, pulled out of the chimney concrete and whipped back within one foot of the vertical.

It is held that for 25 ft. from the base the circular form was retained, while the remainder presented a double-barrelled appearance, with many of the tiles intact. Ten men with sledges immediately began to break up the portion not shattered.

To protect the tracks old ties were placed end to end each side of the rails. The impact did not harm the rails, but it drove the ties under them into the earth about six inches, pulling all spikes in the 15-ft. width which the felled chimney occupied.

Salmon River Development—The New York Public Service Commission, Second District, has authorized an issue of $546,000 of 6-per cent. 3-yr. gold notes, dated Feb. 1, 1916, by the Salmon River Power Co., with which that company will complete the financing of its 30,000-hp. hydro-electric plant on the Salmon River, Oswego County, from which it purposes to supply current to the Solvay substation of the Niagara, Lockport & Ontario Power Co.

Preventing Air Leakage in Orsat Apparatus

It frequently happens that operators of Orsats draw air into a sample unknowingly. The manner in which this is usually done is this: When the sample has been drawn into the machine the water is raised in the burette toward the zero mark to expel into the atmosphere all gas in excess of the necessary one hundred cubic centimeters. This is usually accomplished by holding the leveling bottle at some point below zero at the beginning of the operation and gradually raising it until the water level in the burette stands at zero. Often a slight movement of the hand causes the level to raise a little higher. In most cases there is an unconscious tendency to bring the level back, and the result is an inaccurate sample.

The proper way to avoid this would be to have a tube long enough connecting the leveling bottle to the burette to permit the placing of the former at some higher point than the zero mark, say on top of the instrument case, as may be done with the Duemler instrument which has a spring holder for the leveling bottle. After the sample has been drawn into the machine, allow the water to rise to the zero mark, then lock the sample in the machine. By doing this it is impossible to lower the water and draw in air.

Experience shows that a few drops of japan white, such as is sold in tubes in art stores, dropped into the water in the leveling bottle will whiten it without affecting the sample; the markings on the burette scale will stand out clearly, doing away with the eye strain when taking readings in dark corners and behind boilers.

In the average boiler room where quite high temperatures are common the rubber tubing and bags, if used, get hard and easily crack when handled.

Isolated Hydro-Electric Plant

By Walter Swaren

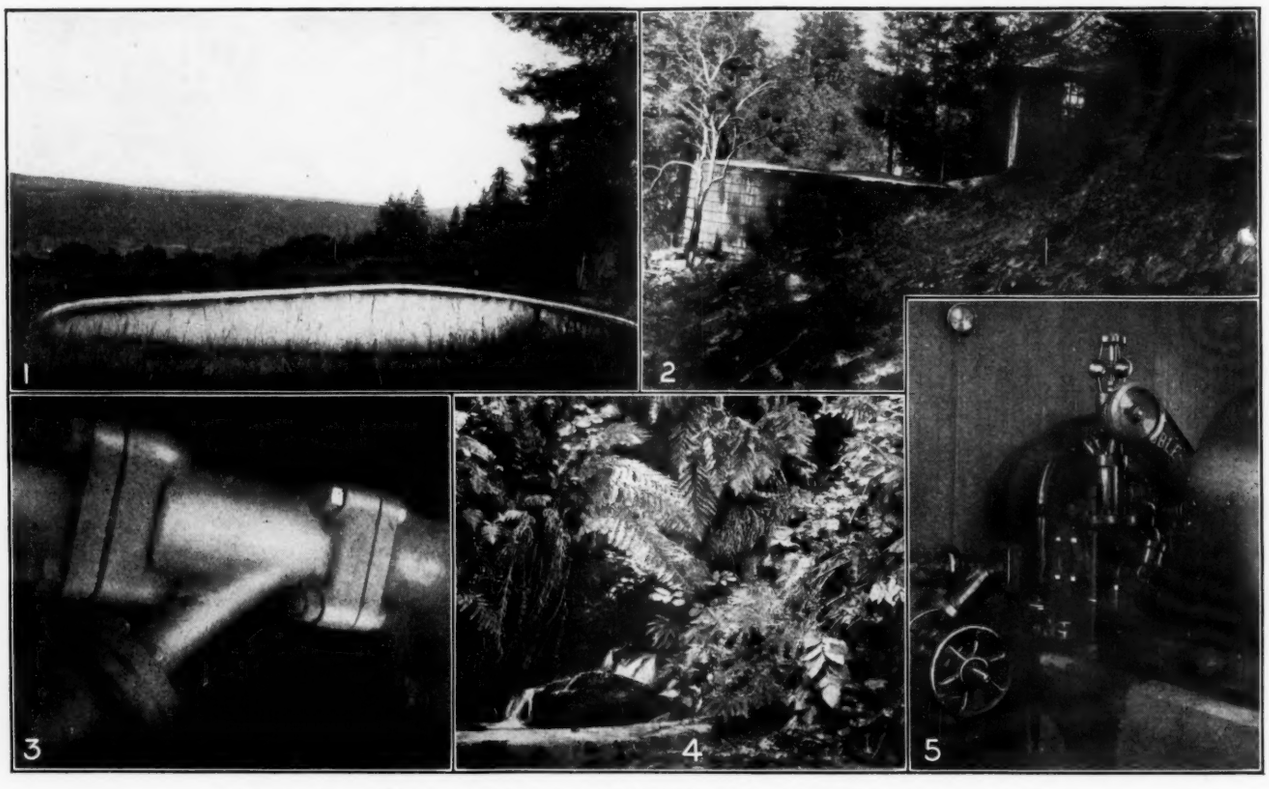
SYNOPSIS—It has been estimated that more than 12,000,000,000 hp.-hr. is expended annually in farming operations. How one farmer has supplied himself with both potable water and ample power for all purposes is shown in the description of a miniature hydro-electric plant on a ranch in California.

The ranch of J. A. Folger, near Woodside, Calif., covers an area of 1,400 acres composed partly of hillslope land rising about 700 ft. above the valley and covered with redwood trees, which makes an ideal watershed. Near the highest point about a dozen springs issue from the ground. The water from some of these is caught up by concrete dams, while that of others flows directly into wooden boxes. The largest of these springs has a flow of about 200 gal. per min., while the flow from some others does not exceed 5 gal. per min. For the water-supply of the ranch, pipes of a size suitable for carrying the minimum flow from each of these springs are laid to a common water main which discharges into a 10,000-gal. redwood tank. The excess flow is turned over a weir into the natural water course that traverses the ranch and is utilized as explained later.

The flow of these springs is always somewhat greater than the maximum requirements for domestic supply, so there is a continuous overflow from the tank, this excess of course being much greater at night. The overflow is conveyed by a 4-in. pipe to a reinforced-concrete tank of 700,000 gal. capacity set in an excavation near the main water tank and 450 ft. above the house, farm buildings and shops. The domestic water-supply is carried down the hill in a pipe line to a pressure-reducing tank of 1,000 gal. capacity set on the hillside at an elevation of approximately 75 ft. above the farm buildings. The plumbing is connected in the usual manner to the main leading from this tank.

As previously mentioned, the excess flow from the springs is turned into the natural watercourse. About 600 ft. downstream from the largest of these springs, this water is picked up by a flume, placed where the stream bursts through a rocky ledge and forms a narrow gorge which effectually holds in check débris washed down from above during flood time. No dam is installed, the intake works being merely an open box over which the water flows during periods of high water. With low water a few shovelfuls of earth thrown about the upper end diverts the entire stream. This box is weighted down with rocks, and owing to the protection of the gorge, is not swept away during periods of high water.

The flume is approximately a mile long and is carried on a contour line about the brow of the hill to a point near the reservoir, where it enters a short line of vitrified tiling, whence the flow is conducted to the reinforced-concrete reservoir. From this reservoir a line of 5-in. wrought-iron pipe leads to the farm buildings below. About 1,400 ft. from the reservoir and near the



FIGS. 1 TO 5. VIEWS ALONG THE HYDRO-ELECTRIC SYSTEM ON THE RANCH

Fig. 1—Reinforced-concrete reservoir. Fig. 2—One of the tanks in which water is collected after discharging from the wheels. Fig. 3—Special Y-branch. Fig. 4—One of the numerous springs. Fig. 5—Main water-wheel unit

pressure relief tank for the domestic water supply, this pipe line is tapped by a specially constructed Y. As the 5-in. pipe line was in place and buried in a trench when it was desired to put in the Y-branch, it would have been difficult to thread the main pipe line, and the expense of taking up a part of it would be prohibitive. The difficulty was overcome by the special fitting shown in the illustration. This is merely a double stuffing-box, one on either end of the fitting, with the customary gland and followers arranged to slip over either end of the pipe when a short piece is taken out. The glands are packed with hemp and the followers drawn up tight in the ordinary manner. The branch is arranged with a standard flanged fitting, which also serves as an expansion joint in the pipe line.

Main Waterwheel-Driven Unit

This 3-in. pipe supplies water to a 22-hp. Pelton-Doble waterwheel directly connected to a 15-kw. 125-volt direct-current generator. Accurate speed regulation is maintained by a type O Pelton-Doble oil-pressure governor. Water economy, which is essential in an installation of this sort, is obtained by a hand-operated needle nozzle, while the governor actuates the deflector. The man in charge of the plant opens the needle nozzle to pass a sufficient quantity of water to carry the maximum load that is expected during the evening; then, with an increase of speed the governor raises the deflector so as to divert part of the stream. With an increase in load the governor drops the deflector, and the full stream or such part of it as is necessary to carry the increased load again impinges on the waterwheel.

The static head at this point is 327½ ft., while with a load of 10 kw. the running head falls to 255 ft. This loss in head is caused by the relatively great length and small size of pipe line; but as maximum load is seldom required, in order to hold the first cost of the pipe line at a reasonable figure it was deemed advisable to make the pipe of this small diameter and accept the loss in head. Should the deflector be required to divert the entire stream when the generator is carrying full load, several hundred foot-pounds would be required to move the deflector through the stream. Even under normal operating conditions the energy required to operate this deflector often will be in excess of 100 lb. Obviously no type of centrifugal governor could economically supply this quantity of energy; therefore an oil-pressure governor, as previously mentioned, is used.

Regulation by Oil-Pressure Governor

The operation of the oil-pressure governor is as follows: The centrifugal element, consisting of a standard Gardner governor head, is driven by a belt from the shaft of the waterwheel. The stem of this governor operates a double needle valve, which admits oil under pressure to either end of the cylinder. The piston of this cylinder through a bell crank actuates a rockshaft which extends through the governor case and the casing of the waterwheel and carries a jet deflector. Movement of the governor piston, which is controlled by the centrifugal element, will divert more or less of the stream from the waterwheel.

The oil under pressure required for the operation of this piston is supplied by a small rotary pump, which is also belt-driven from the mainshaft of the waterwheel. This oil being constantly pumped under heavy pressure, becomes quite warm; hence the discharge of the pump passes through a long bend in the wheel pit, so that the water discharging from the wheel serves to cool the oil. This extra length of pipe also provides an oil-storage reservoir of sufficient size for this type of governor.

The water, after its discharge from the wheel, is conveyed by a short flume into a series of large redwood tanks just below the power house. These are of sufficient capacity to store all of the water that will pass through the waterwheel in 24 hr. when the wheel is operating at its maximum load. The water from these tanks is used for replenishing the supply of the large swimming pool near the house and for irrigation purposes.

At certain periods the flow from the springs is not enough to operate the electric plant, therefore the flow in excess of that needed for domestic purposes during the daytime is stored in a reinforced-concrete reservoir, while the electric-lighting plant is shut down about 9 or 10 o'clock so that the entire flow of the springs during the remainder of the night replenishes the reservoir, thus providing ample water for the next night's lighting.

In addition to the waterwheel mentioned, there are several smaller ones for other purposes. The 5-in. pipe line that leads from the reservoir is carried on to the farm buildings, an additional distance of 1,000 ft., where a static head of 450 ft. is available. Here is installed a 12-hp. water motor, belted to a lineshaft which drives a wood saw, a grindstone and a few other small tools. Another water motor of 5 hp. is installed in the dairy, while a third drives a 5-kw. electric generator which is held in reserve.

The entire work was done under the personal direction of Mr. Folger, and no other labor than regular employees on the farm was used.

New Rear-Arch Construction

A new arch construction patented by Louis Bernhard, 141 Milk St., Boston, Mass., aims to provide an arch for boiler settings, dutch ovens, etc., that will not crumple and fall from place.

The construction consists mainly of a combination bridge and arch, the latter being below the bridge with a space between them to allow for the expansion of the latter. The inner arch is supported by the outer one, with provision for taking care of the relative movement of the inner arch during expansion and contraction.

Referring to Fig. 1, which is a rear plan and sectional elevation of a regulation combustion chamber, a firebrick lining is shown at *A* and the position of the fusible plug in the rear head of the boiler is at *B*, a few inches below the arch. The inner arch consists of firebrick *C* and firebrick binders *D*.

A layer of magnesia *E* is placed on top of the under arch and serves as a bed upon which the outer arch is built. The latter is made of ordinary bricks *F*, above which is the brickwork *G*. The outer arch is connected to the inner one by the binders *D*.

When the arch is first built, as shown in the elevation view, the binders, which are made wedge-shape at both ends with straight surfaces adjacent to the magnesia, fit tightly in the lower arch, but they have a slightly loose fit in the upper one and can expand in the space *J*.

When the boiler is in operation the magnesia contracts and leaves a space *H*, Fig. 2, between the two arches so

that the inner one can expand toward the outer one. The binders will also expand in the direction represented by the dotted lines in the space provided in the top brick covering, as shown at the right of Fig. 2.

When the inner arch contracts, it will move away from the outer one, but the magnesia will remain in its con-

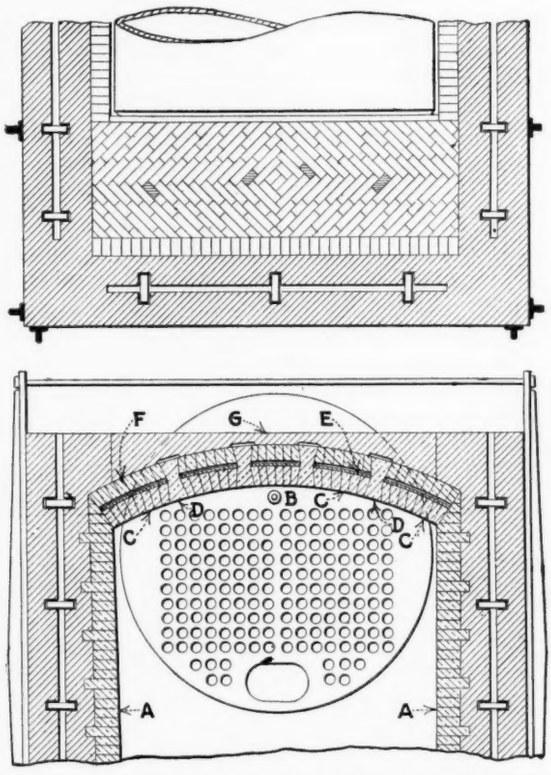


FIG. 1. PLAN AND ELEVATION OF BACK CONNECTION

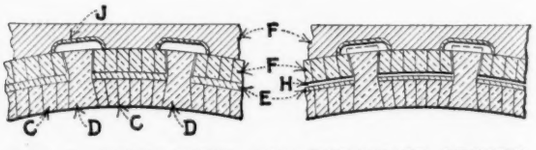


FIG. 2. CONTRACTED AND EXPANDED ARCHES

tracted condition, so that the space *H* remains to take care of the next expansion of the inner arch. When the arch is reduced in temperature, the binders will contract and be lowered, during which movement the lower wedge will spread the inner arch slightly, holding it firmly against its abutments. The binders *D* have a reinforcing and supporting function as to the inner arch and during the movement of the inner arch a steadying function.

Suggestion for Cub Engineers

By W. D. Forbes

In a certain big hotel in New York, built from plans made by an architect, the general arrangement was admirable, including the plans for the radiators. Two large piping concerns were given the plans to bid on connecting up the radiators, steam tables, bathrooms, etc., including the boilers. The job was done, tested and accepted, but trouble soon arose. Some rooms were too hot and some too cold, and after considerable correspondence and talk with the architect and piping people, the owner decided to find someone to overhaul the job.

A man who was recommended to the owner of the hotel and who had had experience in revamping troublesome heating apparatus said he was pretty sure that the piping had not been done according to the plans and soon proved that he was right. Among the men sent to the job was a young fellow who acted as a helper and sort of timekeeper. He was a technical graduate, but it had not done him much harm, and he had been wise enough to say nothing about it, because his father a few days after the boy had graduated had given him a heart-to-heart talk and told him to go and get a job and learn something and say nothing about college.

Shortly after this job was put in good working order, the engineer of the hotel left suddenly and the owner had to get another man, and for a week there were many complaints concerning the heating. The new engineer soon found that the piping did not agree with the plans. Just as he got a pretty good understanding of things, he was offered a better job and left, so the owner had to find another man and go through the same performance. Spring was coming on, however, and heat not being needed, things went smoother, but the third man gave notice that he was going to leave.

Corrected Plans Eliminated Trouble

At that moment the young technical graduate appeared (just at the right moment) and told the owner that he thought he could help him out of his troubles by making a drawing of the piping as it really was, numbering all the leads and runs of pipe, showing all the valves in their proper position, and painting the pipes various colors so as to indicate whether they were live steam or returns. Any engineer could then in a few hours learn to manage the plant. The owner caught on to the idea, and the young man started in. At the cost of about $250 he so arranged matters that the owner, if he had a complaint from any floor, could telephone to the engineer to open or close certain valves, and that ended the trouble.

Not long afterward a friend who owned a large apartment house dropped in with a long tale of woe concerning the heating apparatus, with the result that the young man got another job. Before very long he had to employ a couple of draftsmen to help him, and he soon had all he could attend to in this line. He was urged to go into the piping business, but declined to take up the burden of looking after gangs of pipers and sidetracked the idea. The condition described is pretty well known, and the cure is very simple. There may be a good many men who undertake this work, but if so, they seem to hide their lights under a bushel, as they do not advertise in any technical paper devoted to piping and boilers, and here they make a mistake.

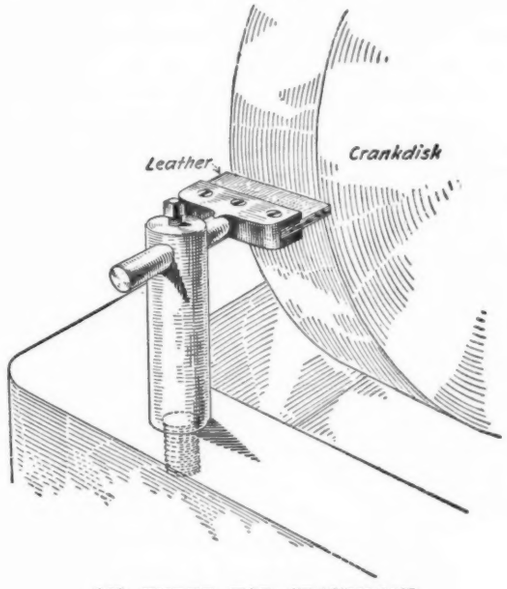
Probably there is in every great city an opportunity for men who can undertake the work described to gain a handsome living and save owners a lot of trouble and annoyance.

Anyone can understand how it is often the case that piping is not put in as originally planned. Uncharted beams and girders and other obstructions require modifications in piping plans, and of course, when made, they are rarely if ever noted on the original plan, and even if they were, those who do piping do not hand to the owner a chart that will enable him to intelligently direct the heating of an establishment from the office. There may be objections to this, although it does not seem likely.

Engine Crankdisk Oil Wiper

It has been some time since anything relating to oil wipers on the engine crankdisk has been published in *Power*. The illustration shows how one engineer arranged to prevent the crankdisk of his engine from throwing oil.

A hole was drilled and tapped in the engine base in line with the crankdisk. In this hole a ½-in. round stand



OIL WIPER FOR CRANKDISK

was screwed. The top end of the stand was drilled with a ⅜-in. hole in which the wiper rod fitted and was held in place by a small setscrew in the end of the stand. The wiper rod was made with a wide split flat head, in which a piece of leather was secured by screws and nuts. The rod and leather were so adjusted that the latter bore against the rim of the crankdisk, and as the disk revolved, any oil finding its way to the face was wiped off and the throwing of oil was thus prevented.

⁂

Good Oil Without Adulteration, if used intelligently, is cheaper and more satisfactory than cheap oil, loaded to give bulk and to make it cost less per gallon.

⁂

Bursting Pressure in Pipes, or the force tending to rupture them, is calculated like that in boilers or other cylindrical vessels, the three considerations being the pressure per square inch, the number of square inches it acts upon and the ability of the metal to resist it. The first may be directly stated as pounds' pressure or may be given in feet elevation of the fluid contained, which is converted into pounds by multiplying the feet height by the specific gravity of the fluid per foot of height. The area acted upon by the pressure is for convenience usually taken as 1 in. of pipe in the direction of its length multiplied by the diameter of the pipe (the length being unity, no multiplication is performed, simply the diameter taken). This gives the square inches to be multiplied by the pressure per square inch, which is the total force to be resisted by the metal on the two sides of the pipe, or ring. The sum of the thicknesses of the metal on the two sides represents the square inches or parts of a square inch involved, the other dimension, as before, being unity. Should the pipe walls be ½ in. thick, for example, there would be 1 sq.in. of metal to resist the strain. The tensile strength of the metal then determines the ultimate failure of the pipe. For safe working pressure a factor of safety of 6 to 10 is allowed, or the pipe is only required to carry a working pressure of ⅙ to $\frac{1}{10}$ of the final bursting pressure as obtained by calculation as described or by tests to destruction. Tables giving the tensile strength of various materials may be found in engineer's handbooks and applied to the foregoing problem.

Government Power Monopoly in Germany

By Ludwig W. Schmidt

Among the propositions toward relieving excessive taxation after the war in Germany, the creation of a power monopoly has been suggested. Reports now coming from Germany indicate that these projects find increasing support on all sides. In opening the Diet of Saxony, the King said that a firmer and more concentrated organization of the electrical supply of the country would be necessary, and that the government had already decided to take steps to carry out such a project. In Bavaria the matter has gone still further, a parliamentary financial committee having already authorized the starting of a large hydro-electric plant on the Walchensee.

Both water power and steam have been considered. An objection to the former is that, although a few of the large rivers might offer opportunities for hydro-electric development, they are more useful as inland waterways, and the erection of large dams might interfere seriously with the working of the complicated canal system connecting the different natural waterways throughout Germany. With the exception of certain minor streams and lakes in a mountainous section, as in the case of Bavaria, the rivers will probably not be interfered with. Steam power, however, seems to hold better promises, and it is proposed to erect large power plants at suitable places where coal can be obtained easily and cheaply, and to transmit the electrical energy to the industrial centers.

States Will Control for the Present

The first intention in creating a power monopoly in Germany was that of making it an enterprise of the empire. Now, apparently, the individual states have taken the matter into their hands, although it is claimed from some sources that this is only a preliminary step, and that finally the whole system will be concentrated under the control of the empire.

In carrying out the project the government will have to meet the competition of the present private and municipal enterprises without seriously hurting vested interests of long standing. It might do so by acquiring these interests or by slow assimilation. The first seems to be very improbable, because of the large capital invested and also because many of the plants are connected with other enterprises, such as electric railways, the acquisition of which is not intended. It is planned to put these governmental plants on a thoroughly commercial basis, and it may therefore become an advantage for the existing enterprises to buy their energy from the government plants or, in the beginning, to buy power from this source to supplement their present capacity. It is thought that after a while the situation will be sufficiently ripe to concentrate all the power supply into the hands of the central government.

⁂

Friction of Lubricated Surfaces is determined by the nature of the lubricant rather than by that of the solids or bearing metals themselves.

⁂

Antifriction Metals, so called, are useful for lining bearings chiefly because of the ease with which they can be formed (poured) and their ability to permit crushing and abrasion without great increase in friction, not because they have a lower coefficient of friction; hence antifriction is a misnomer.

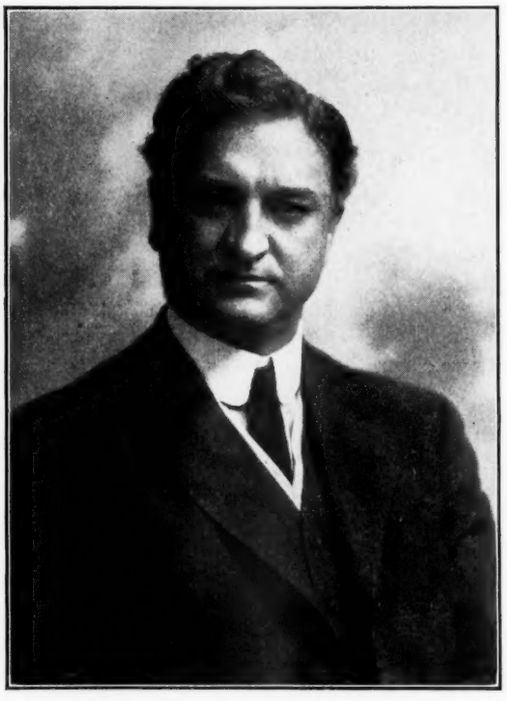
The Use of Armature Bands

By Gordon Fox

The bands on an armature are for a single purpose—to retain the coils in shape and position. They are a necessary evil, present only through mechanical need. Insofar as they can be replaced by other means, a gain is made in simplicity and reliability. For the larger generators and motors wedges are being used largely to retain the portions of the coils embedded in the laminations, and the small fractional horsepower motors utilize wedges exclusively upon their armatures.

Bands are undesirable for several reasons. Requiring space in the air gap, they reduce clearances and are liable to serious injury through obstructions that may find their way into the air gap. Owing to expansion or other cause they are likely to become loose and displaced. Failure of a band is likely to free the coils and lead to serious damage. Steel bands cause closed magnetic circuits around the coils increasing self-induction, and eddy currents in the bands introduce losses. The metallic circuit from coil to coil, separated by insulation under compression, often leads to short-circuits. Repairs are made more difficult because of the necessity of removing several bands in order to gain access to a single coil. To the manufacturer, complication may be introduced through the necessity of recessing the laminations to receive the bands, a practice requiring two sizes of laminations. In view of these several drawbacks the use of bands may well be confined to heavy-duty machines, high-speed armatures, end connections and to such designs as cannot well be otherwise cared for. Where bands are used, they must often be replaced incidental to coil repairs. A few points in this connection will be suggested. One point deserving mention is the means of securing the desired tension. This is usually accomplished by clamping the banding wire between blocks, allowing it to slip through against friction. This method is open to the objection that the wire becomes heated in sliding through the clamps and is consequently expanded. It is wrapped tightly upon the armature while hot and upon cooling is likely to become too tight, so that it will stretch or break. It is difficult to secure a definite tension by this method since the temperature of the wire plays a determining part. A better plan is to wrap the banding wire about a drum and to cause friction opposing the unreeling of the drum. The heating effect of the friction is then dissipated elsewhere than in the wire, the latter remaining cool and under a definite and controllable tension.

Another detail, small but important, is the location of the clips used to anchor the bands. The first step in the banding operation is to wrap an insulating strip a little wider than the band once around the armature, holding it in position with a drawn cord. Under this cord are slipped a few narrow strips of brass or copper about 1½ in. long, the longer dimension being parallel with the shaft; the band is then wound over these clips. They are bent upward and inward over the band, being tapped lightly into position, after which they are soldered. There should be but a limited number of these inclosing clips upon each band. The reason is apparent when it is considered that the band wires are conductors rotating in a magnetic field which do not cut any magnetic lines as they are not parallel with the shaft; but the anchoring clips are conductors so placed that they do cut magnetic lines. The band wires act as end conductors, thus completing little short-circuited coils through which the currents can flow. If the clips are so located that one is under a north pole when another is under a south pole, there will be considerable resulting current, which will cause heating, losses and perhaps loosening of the band. It is evidently advisable to locate the clips on a four-pole armature diametrically opposite one another, so that they will be in similar magnetic fields at any time. Likewise a six-pole armature should have three clips per band, located 120 deg. apart. Some repairmen make it a practice to solder or tin completely the surface of all bands. This is not good practice, for the reason that a band is thus totally short-circuited and heavy currents are likely to be generated within it. In soldering band wires—in fact, for all soldering about the windings of an armature—it is best to use a neutral soldering paste or a flux made up of rosin dissolved in alcohol. Soldering acids should not be used since any leakage is likely to decompose the insulation. Upon many of the larger armatures of recent design the bands over the end connections are replaced by single steel straps. A joint is made by means of a tension lever and a simple latch. The main advantages of the strap over the wound wire band are ease of removal, availability for repeated use and ease of application with minimum equipment. These single-strap bands can often be applied to take the places formerly occupied by wound-wire bands, the change being made during a repair operation that requires the removal of the armature bands. Phosphor-bronze is sometimes used for these straps. In some of the older types of machines the bands were wound over strips of insulation consisting of vulcanized fiber and mica. With a smooth-core armature a considerable strain was put upon the bands for they had both to keep the windings in place and resist centrifugal force. With an increased diameter of the armature, the diameter and the number of strands making up each of the bands also increased although not proportionately as the speed usually decreases with an increase in armature diameter.



ARTHUR J. BALDWIN
The new president of the Hill Publishing Co.

Editorials

Our New Leader

Arthur J. Baldwin has been elected president of the Hill Publishing Company to succeed the late John A. Hill.

Mr. Baldwin is a lawyer by profession and is associated with ex-Attorney-General and Governor Griggs in the firm of Griggs, Baldwin and Baldwin. In addition to his legal practice he fills important positions in the world of business, among them being that of treasurer of the Rogers Silver Plate Company; treasurer of the Borough Development Company, which has a contract with the City of New York for the removal of ashes from the Borough of Brooklyn; treasurer of the Boston Development and Sanitary Company, which handles all the garbage and ashes for the City of Boston; vice-president of the Automatic Fire Protection Company, and secretary of the Mississippi Wire Glass Company.

Notwithstanding the eminence which he has attained as a lawyer, Mr. Baldwin's views have not been stunted by his profession, nor have his studies and observations been confined to the calf-bound volumes of the law. His extensive investments in industrial enterprises have been uniformly successful because he has given largely of his time and energy to those enterprises, and for the past six or eight years he has been more active in business than in legal circles. Although supposedly only the legal adviser of the company, he shows a knowledge of the traditions, the policies and even the details of the business which surprises his new associates and warrants the inference that he had been so identified with the various steps in its progress as to guarantee the continuance of its administration on the fair, broad-minded, high-toned and progressive plane upon which its founder left it.

He possesses the quick insight into fundamentals, the sound judgment of men and of measures, the ability to decide and the force to execute which characterize men accustomed to deal with large affairs, and withal a personality that promises to endear him to a force accustomed to more than an ordinary degree of humanity in their leader. He is giving up his law practice and curtailing his other activities with a view to devoting himself principally to the direction of the Hill Publishing Company. We are confident that the affairs of the company and the interests of our patrons will be safe in his charge and that the respect and esteem of our clients will grow with their knowledge of him.

How System May Be Overdone

Periodical repairs, replacements and overhauling are the rule in most power houses. A regular system of doing things at specified intervals is considered the efficient method of keeping a plant in good operating condition. This is wise if not so strictly followed that little things needing to be done are deferred until the set time. The knowledge that a week or a month hence certain comprehensive inspection and overhauling is to take place frequently provides an excuse for letting things slide and getting along as well as possible until the needed repair or operation is scheduled.

Lack of accessories may frequently largely control the small wastes and inefficiencies, particularly in the smaller power houses. The chief value, if not the object, of such accessories is to prevent the small leaks, not the large ones. A typical illustration, which unfortunately is found in many plants, is failure to remove oil from the condensate before it is fed back to the boilers. Oil separators or grease extractors should be installed, but in many plants of moderate size are deemed an unnecessary expense because the boilers have to be cleaned out every few days anyhow. In the meantime deterioration within the boiler has been accelerated, but because it will be arrested, supposedly, before it becomes rapid or serious, the removal of the cause before it can usually do any great damage is considered sufficient. The prevention or amelioration of the cause is better than simply removing it after some of the mischief is done. This is but one common example of small wastes which occur in many plants and which, though perhaps not due directly to the enforcement of a system of overhauling, etc., are frequently aggravated thereby.

The proper course is for the engineer to depend more upon his own knowledge and experience, following the system of inspection and overhauling that has proved satisfactory in the past, but deviating from it whenever advisable. This entails considerable additional work on the part of the power-house force, which naturally raises the question whether many plants are not undermanned. Apparently this is so, even in plants that are operated with a high degree of efficiency.

Not only is the grade of labor for the smaller plant apt to be lower but there is a tendency to impose the care of a larger amount of apparatus upon a man. Power houses of still greater capacity operate most efficiently with a proportional attendance burden which decreases with the size of the plant, it is true, but this is accounted for in that the efficient working capacity of the power-house force is not quite attained in a 2,500-horsepower plant, and that the larger the plant, as a rule, the greater the dependence placed on auxiliary equipment to cut down expenses.

For the smaller plant to compete in efficient operation, it is therefore necessary that either the attendance be increased or more reliance placed on accessories and labor-saving devices. The latter is the cheaper and therefore the logical improvement to make.

The installation of advisable accessories will do more to make possible the enforcement of a system efficiently than anything else; it will lessen the dangers of misapplying the system and cannot fail to result beneficially to all concerned. Nobody knows this better than the engineer, and when the management realizes it as well and coöperates, comparatively high efficiency of the power house will be far more common.

Many engineers make the mistake of trying to get along without equipment which would be helpful to save their

employers expense. An investment of a few dollars, even if it saved little in operating expense, might improve conditions in the plant and lighten labor, making the men more contented and reducing dangers of accidents that arise from neglect of small repairs when the force is overworked.

Oxidation of Fusible Plugs

I have in my office in Washington a murderer who is hung. I keep him there as a warning, and the gallows on which he hangs has upon it a label to the effect that he was hung for killing eleven men.

He is a metal murderer. Technically, he would be known as a fusible plug. He murdered because he did not fuse. He goes into the crown-sheet of a boiler over the fire and his function is, when the water gets below the crown-sheet, to fuse and to let the steam down upon the fire and put it out. He did not fuse. The boiler exploded and killed eleven men.

Why didn't he fuse? Because when he was made instead of pouring tin into the hollow center of the brass plug, the workman, knowing no better and having come probably to the end of the melt which he had in his crucible, poured, instead of liquid metal, the slag which floated on top of it in his crucible. The tin should have melted at 400 deg. or thereabouts. What he poured in would melt at 4,000 deg.; the boiler itself would have melted first. Nobody may have known any better in the foundry where that was made. No one may ever have told John or Jim or James or Joseph, who had that crucible, what the difference in the melting-point of metals was. There was no place where he could learn that he was taking human life by doing what perhaps seemed to him a simple thing to do. Had the foreman known, had the workman known or been able to know what he was doing when he was filling fusible plugs, there would be a chief engineer and some good workmen living today who have passed to their account.

Such was the introduction to an address on the need of broader industrial education, by William C. Redfield, Secretary of Commerce.

That the user of fusible plugs as well as the manufacturer must have more knowledge about them, or put it into practice if he has it, is emphasized in Bulletin Fifty-Three of the Bureau of Standards, having the title, "An Investigation of Fusible Tin Boiler Plugs." Analyses and study of over a thousand plugs, about one hundred of which had been in service, shows that the temperatures to which the plug filling is exposed causes heretofore unsuspected changes in the character of the filling, changes, unfortunately, that are always for the worse.

Tubes containing impure tin or tubes high in zinc, particularly the latter, oxidize and thereby raise the fusing temperature to degrees at which the boiler plate itself will give way under the working pressure. Some times this oxidation is so extensive as to affect the filling from top to bottom. The difference in coefficient of expansion of the casing and the filling is shown to lead to the formation of oxide on the surface of the filling in contact with the wall of the casing.

The fusible-plug specifications of several well-known organizations, professional and governmental, are charged as lax because impure tin or too large quantities of zinc are allowed. The present specifications of the Steamboat Inspection Service, which call for "tin 99.7 per cent. pure, containing not more than 0.1 per cent. of lead and not more than 0.1 per cent. of zinc," are commended.

All too often fusible safety plugs so-called have failed to function owing primarily to lack of knowledge of the behavior of the plugs in service. How often are leaky plugs—plugs that have become seriously defective and manifest their condition by leaking—stopped instead of replaced as they should be. The recent order of the Interstate Commerce Commission that all fusible plugs be removed and cleaned of scale once every month will likely do much toward directing attention to plugs when they are in need of it. Unless the purity and character of the filling for fusible plugs can be dependable to the extent that oxidation or other causes which raise the fusing temperature to dangerous degrees can be avoided, any measure that requires the renewal of plugs before service makes them dangerous is commendable because necessary to public safety.

But fusible plugs are not, in the stirring language of the Secretary, the only "murderers" at large in power plants. There are the weak or cracked boiler joints, the safety valve that is not safe, the engine stop that did not or does not stop, and the safety cams and governor that do not cut off; the high-pressure steam and ammonia lines that stress and vibration have crystallized. And how often, when these have completed their destruction, can the primary cause be traced to carelessness or ignorance on the part of operator, owner or designer?

Recently the tug "Sam Brown," which plied the Ohio River, was shattered by the explosion of its boiler. The news reports stated that all of the crew of ten were killed.

The wonder is, not that the explosion happened, but that boiler disasters aboard these Middle Western river boats are not more numerous. The factor of safety on these boilers is notoriously low, being three and six-tenths to four and six-tenths as a usual maximum. We understand that at least some insurance companies refuse to assume the risks that most of these river-boat boilers constitute. How do those responsible for such conditions excuse or explain them? Others besides the widows and orphans would like to know.

"There are several thousand hot-water tanks in Oklahoma City. Any one of them will behave itself if encouraged; any one of them will burst if given the proper underlying conditions," says the *Oklahoman*. Humph! A lot of fuss about a few hot-water tanks! Why, we know of many cities and states that do not say half as much as this about their high-pressure boilers.

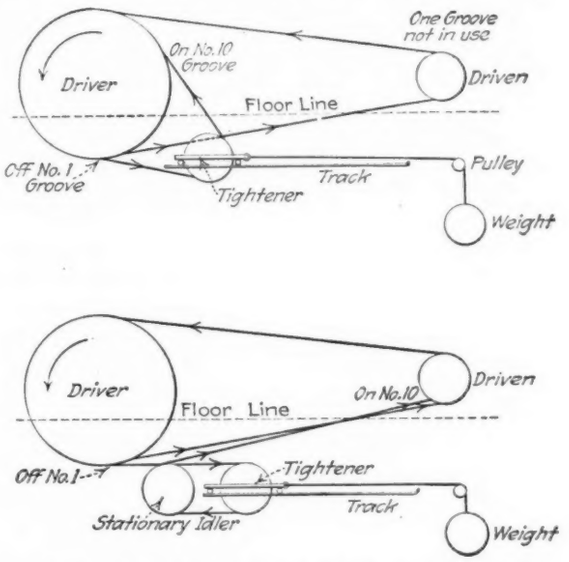
The much-looked for report of the Secretary of Agriculture upon the ownership and control of water-power sites in the United States, the proportion of such water-power sites in private ownership and by what companies and corporations such sites in private ownership are owned and controlled has been submitted to the Senate and placed on file. It would cost too much to print and distribute it; and besides, it is pretty rich diet for the commonalty.

"A heaven-abrading bone-rendering establishment in Central Park is about the only parallel to this barbarous intruder on the charm and comfort of Washington," says the New York *Times* about the Government's optional power plant to be located down on the Potomac. If the shoe were on the other foot an excuse would be found for taking the Washington monument itself for a chimney.

Correspondence

Troublesome Rope Drive Fixed

The illustration shows how a rope drive was originally put on and how the run was changed after it had ruined a new rope in 14 days. In the first case the tension or tightener strand was led off from No. 1 groove on the



FAULTILY DESIGNED ROPE DRIVE CHANGED

driver to the tightening idler pulley, which was set askew, or on an angle sufficient to deliver the rope back to groove No. 10 on the same wheel.

The changed run differed in that the first (tightener) idler delivered to a second (stationary) idler, and this one delivered to groove No. 10 on the driven wheel.

Montesano, Wash. ED. M. KEYS, JR.

Relieving a Steambound Pump

The air- or water-operated thermostat controlling the temperature of the water in an open feed-water heater in a certain plant would sometimes stick and allow the water to become so hot that the feed pump became steambound.

A ⅜-in. pipe with a valve was connected from the cold-water supply to the suction close to the pump, so that the supply water could be cooled down when necessary by the introduction of cold water for a short time.

Newark, N. J. W. T. OSBORN.

Cutting Down Cylinder Oil*

I am interested in the articles regarding the cost of engine lubrication and submit the conditions and amount of oil that our plant (Lord & Taylor) used in connection with the electric-current generating units only, for the year just past. The steam pressure is 140 lb. saturated, and the main steam lines are piped to a Holly system. There are four 450-hp. Corliss engines directly connected to 300-kw. generators, operating at 100 r.p.m. with a piston speed of 700 ft. per min. The cylinder diameter is 20 in., and in a 24-hr. run about 1¾ gal. of cylinder oil is used which costs 30c. per gal.

The oil is fed into the cylinders by force-feed lubricators. The main, crank and outboard bearings, eccentrics, crosshead and guide are fed from a gravity tank which takes care of the engine-oiling system. The oil is kept cool by a brine coil in the tank and is used over and over again, being replenished as needed. This oil costs 21c. a gal. About 3 pints is used on the releasing gear, etc. in 24 hr. and is taken from the main oiling system. Grease is used in cups on the rocker arms, governor pulley, etc., and less than 1 lb. a month is used on all the engines. The grease costs 11c. per lb.

The four engines are operated alternately 36 hr. each, on an average of 180 hr. a month. For 9 or 10 hr. a day two engines are run and for the rest of the time—nights, Sundays and holidays—one engine. The total amounts and cost of all oils and grease used for the year just past are as follows: Cylinder oil, 697 gal. at 30c., $209.10; engine oil, 445 gal. at 21c., $93.45; grease, 10 lb. at 11c., $1.10; total cost, $303.65.

The total electric current generated in the same time was 1,929,635 kw.-hr., which makes the cost of lubrication per kilowatt-hour $0.00016, or 16c. per 1,000 kw.-hr. generated. R. E. EDWARDS.

New York City.

I read with interest Mr. Hawkins' article on cutting down cylinder oil in the Jan. 4 issue of *Power* and am submitting data along similar lines relating to rolling-mill engines and a generator engine carrying a rolling-mill electric load. The data are not the result of a special test, but of the actual operating oil consumption which has been established for more than twelve months.

The rolling-mill engine works with steam at 130 lb. pressure. The cylinder is 30x48 in., piston speed 720 ft. per min. at 90 r.p.m. The area of the walls wiped over in 10 hr. is 3,931,200 sq.ft., valve not included. Three quarts of 40c. per gal. oil is used in 10 hr. The steam traverses 600 ft. of piping, and the condensation is trapped in a receiver-separator close to the engine but above the throttle valve. The separators are drained by steam traps. The average approximate load is 750 hp., making 7,500 hp.-hr. on 3 qt. of cylinder oil.

The Corliss rolling-mill engine works with steam at 130 lb. average. The cylinder is 20x30 in., piston speed 625 ft. per min. at 125 r.p.m. The area of the walls wiped over in 12 hr. is 2,256,200 sq.ft. Three quarts of 40c. cylinder oil is used in 12 hr. The steam traverses 500 ft. of piping, and condensation is trapped in a receiver-separator above the throttle and relieved by a steam trap The average approximate load is 350 hp., making 4,000 hp.-hr. on 3 qt. of cylinder oil.

*See "Power," Nov. 2, 1915, p. 602; Nov. 30, 1915, p. 673; Jan. 4, 1916, p. 23; and Jan. 11, 1916, p. 53.

The tandem-compound engine piston valve uses steam at 130 lb. The cylinders are 14¼&24x21 in., piston speed 525 ft. per min. at 150 r.p.m. The area of the walls wiped over in 24 hr. is 7,699,680 sq.ft. using 3 pt. of oil at 40c. per gal. The steam traverses 100 ft. of piping, and the condensation is trapped by a separator above the throttle valve and is drained by a steam trap. This engine is direct-connected to a 200-kw. 240-volt generator delivering an average of 3,000 kw.-hr. per day of 24 hr. on 3 pt. of oil. This is the only engine for which I have any accurate data on bearing oil, the consumption of which is 6 pt. of 16c. per gal. engine oil in 24 hr.

Franklin, Penn. J. S. GREEN.

Removing Growth from Screens

Noting that A. V. Youens requests suggestions to prevent a vegetable growth on the screens of his cooling tower, as referred to in the article, "Cooling System for Diesel-Engine Circulating Water," in the Jan. 18 issue, I would suggest that he add a few pounds of copper sulphate or soda ash to the system, experimenting until the right solution is obtained.

I have had similar troubles with ammonia condensers located on roofs exposed to sunlight and supplied with salt water, and found the growth hard to remove. Later I hit upon the plan of shutting the water off a few of the stands for a day or so, thus allowing them to dry; the growth would then dry up and die, and on turning the water on again it would be washed off. Alternating the stands, I soon had them all clean. W. T. MEINZER.

Brooklyn, N. Y.

Pipe-Fitting Suggestions

Referring to the article on "Pipe-Fitting Suggestions," by W. D. Forbes on page 895 of the issue of Dec. 28, 1915, I cannot agree with him regarding the merits of screwed and flanged fittings. The weak part of a screwed fitting is that it has a tapered thread, and when a pipe is screwed into it the pressure tending to burst the fitting is enormous. In fact, I have seen two 4-in. elbows burst in the last two days—one while being made up, the other after it had been made up for some time, showing that the strain does not ease up to any extent with time. Malleable fittings stretch to such an extent without splitting that very little trouble except leakage is encountered in using them.

A flange has enough stock so that there is very little danger of breakage, and for high-pressure work it is the safest by a large margin. Mr. Forbes says that there are 56 pieces and 6 chances of leakage in a 4-in. flanged tee, which is correct, and that there is only one piece and 3 chances of leakage in a 4-in. screwed tee, which is correct so far as the fitting alone is concerned, but fails to consider that usually when a screwed tee is used there must be at least two flanged unions used and that each union consists of 2 flanges, 8 bolts and 1 gasket, with 3 chances for leakage. Without question any pipe line above 4-in. can be more easily built, is much more pleasing to the eye and much safer if flanged than if screwed. The ease with which pipe sizes may be changed in lines fitted with flanges is another advantage. For example, if you wanted an 8x6x6-in. flanged tee, a straight 8-in. can be used with reducing flanges and, should it become necessary at some other time to make one of the outlets 8-in., it is only necessary to change flanges.

Every pipe line should be so constructed that it can be taken apart, cut into or removed with the least expense without sacrificing safety or making the first cost too high. There are very few pipe lines that have not been changed in the last ten years, and most of the screwed fittings taken down are in the junk pile, while the flanged ones are still in use or in condition to be again used. H. G. SCHULER.

Kansas City, Mo.

Boiler Performance at Boston Woven Hose and Rubber Co.

I have read with interest the results of tests at the plant of the Boston Woven Hose and Rubber Co., as reported by J. C. Long in the Jan. 4 issue.

Commenting on Mr. Long's closing paragraphs, I believe that most of us will have to sharpen something besides pencils if we hope to wrest the boiler and furnace efficiency championship from him. However, true results are not gotten with a sharp pencil and a pad of paper. Mr. Long has opened a large field for discussion, and his "Summary of Tests" is interesting, but by no means as instructive and helpful as it would have been if accompanied by a description of his methods.

I operate a railway and lighting plant and our service is continuous, so we desire to reach a high average efficiency, and I feel that Mr. Long is claiming a championship on results for test periods only, which do not tell the story of average monthly efficiencies including periods of banked fires, etc.

Some of the interesting and instructive things that Mr. Long might have included would have been: The length of each test; type of boiler and setting; type of grate, whether hand- or stoker-fired; pounds of coal burned per square foot of grate per hour; intensity of draft over fire and drop through the boiler; also whether the draft was mechanical or natural pressure under the grate if forced draft was employed; whether the tubes are blown by hand or by mechanical blowers in the setting, and how often tubes are blown; if trouble was experienced with clinkers; if so what method was employed to minimize the trouble if the fires had to be cleaned during the test.

In our plant we have seven vertical water-tube boilers hand-fired and two horizontal water-tube boilers fired by chain-grate stokers. The fuel is Shawmut slack and anthracite screenings, the cheapest fuels of their respective kinds that can be purchased; the mixture on the hand-fired grates is 80 per cent. anthracite and 20 per cent. slack, while on the stokers we are successfully burning 50 per cent. of each. Both grades of coal run about 13,000 B.t.u. and from 11 to 13 per cent. ash.

On the stoker-fired plant I have tried out several grades of bituminous coal and finally selected one having 35 per cent. volatile and which easily coked, the object being to secure a coal that would produce a good coke to fuse with the anthracite, this being one of the conditions that must be fulfilled in order that the anthracite may be burned successfully on the chain grates. Experience has taught us that the mixture must be fully coked on the coking plates and that no green coal be allowed to fall on the grate proper.

We have been able for six or eight hours to force our boilers 175 to 200 per cent. rating with this mixture, but after a time the clinker gives trouble unless the fires are carefully handled. The hand-fired boilers use forced draft, while the stoker-fired use induced draft.

We have compound differential draft gages on both stoker installations and find them a help in gaging thickness of the fuel bed. Our best results have been obtained with about 0.8 in. water draft over the fire, in other words a drop through the fire of 0.8 in., while the drop through the setting for this fire drop is about 0.6 in. of water; our boilers are the ordinary three-pass setting. This draft no doubt seems high to those not experienced in burning anthracite. Under these conditions we have no trouble in maintaining an average of 12.5 per cent. CO_2.

I should be pleased to see articles in *Power* on burning anthracite dust either on hand- or on stoker-fired grates; also articles on methods for overcoming clinker trouble. C. B. HUDSON.

Ithaca, N. Y.

[*Power* will be pleased to publish articles on these subjects by those who can treat of them authoritatively.—Editor.]

Diagrams Without an Indicator

I was in Canada recently installing a second-hand engine and naturally wished to satisfy myself as to its condition and what might be expected of it like "Will Quizz, Jr.," in the issue of Dec. 14, 1915, page 822.

The engine was 8x10 in. and had a Rites governor, a double-ported slide valve and a pressure plate with ports in it corresponding to the main steam and exhaust ports. My indicator was in the United States, and had I sent for it, there would have been a duty charge of 37½ per cent. of its value, in addition to the express charges. Besides, the engine was not tapped for indicating, nor was it piped up to the boiler when my part of the work was finished, so I decided to do the indicating with a two-foot rule. Accordingly, "indicator cards" were prepared having ten equally spaced vertical lines, and as this engine had a 10-in. stroke, each space represented 1 in., or one-tenth of the stroke.

After removing the steam-chest cover and pressure plate, a two-foot rule was laid on the frame of the engine close to the crosshead and parallel with the guide. The engine was set on one center and the end of the rule adjusted to one corner of the crosshead. The flywheel was then turned ahead until the steam port was just closed. Reference to the rule showed that the crosshead had traveled just 7 in., thus establishing point No. 1 on the diagram on the line corresponding to seven-tenths of the stroke, Fig. 1. Turning the engine ahead until the exhaust was just beginning to open, it was found that the crosshead had moved to the 9-in. mark on the rule, establishing point No. 2. Going ahead until the exhaust port was again closed brought the crosshead back to 1½ in., and point No. 3 was plotted off. When the expansion and compression curves were supplied, the diagram was finished.

Fig. 2 was obtained in the same way from the same engine, but with the governor blocked for an earlier cut-off, and in Fig. 3 the governor was blocked still farther around. As the diagrams from the two ends were found to be almost exactly the same, the valve was considered to be correctly set. B. COPPING.

Kankakee, Ill.

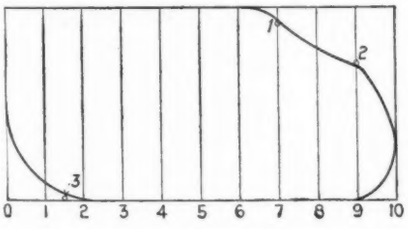


FIG. 1. GOVERNOR NORMAL

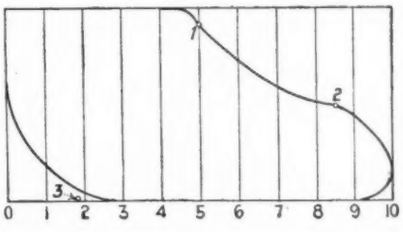


FIG. 2. INTERMEDIATE POSITION

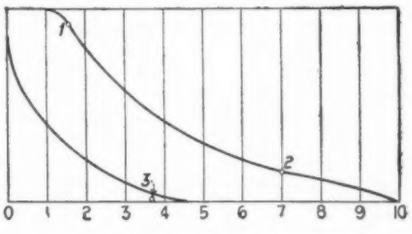


FIG. 3. NEARLY TO EXTREME

Tungsten vs. Carbon Lamps

An editorial in the Nov. 23, 1915, issue took cognizance of the fact that the central station would not overlook the type of lamp in use in making a test on an isolated plant to determine whether central-station service could be substituted for isolated-plant service. These same central stations, however, in many cases agree to furnish new lamps free of cost to patrons using their service exclusively, but these lamps are in most cases of the carbon or gem types using 3 to 3.5 watts per candlepower, which in the end is an expensive proposition to the user, although it does help to boost the central-station load.

Assume that a small building requiring, say, one hundred 32-cp. lamps is using central-station service and taking advantage of the free renewal plan. Carbon or gem lamps are used because as a rule this free-renewal plan applies only to these types and to tungstens in the larger sizes.

The efficiency of the gem lamp is 3.1 watts per candlepower, or approximately 100 watts per lamp. The life of these lamps is about 600 hr., and if 100 are used, the energy consumed during their life would be $\frac{100 \times 100 \times 600}{1{,}000}$ = 6,000 kw.-hr. If this costs 6c. per kw.-hr. (and a building using this small amount would probably pay more) the cost during the life of the lamps would be $360. At the end of this time, however, the lamps would be renewed free of cost.

If 40-watt tungsten lamps of 30 cp., which give about the same amount of illumination, were used, and paid for by the consumer, the cost would be less. The average life of these lamps is 800 hr., but as they are more fragile than the gem, take it at 600 hr. as a conservative estimate. The efficiency is about 1.3 watts per candlepower for small sizes, or 40 watts per lamp, and

the current used during the life of the lamps would be $\frac{100 \times 40 \times 600}{1{,}000} = 2{,}400$ kw.-hr., which at the 6c. rate, would cost $144. In addition to this there would be the cost of the lamps, which in this vicinity is about 30c. each in small quantities, or $30 for 100 lamps. This brings the total up to $174, or a saving of $360 — $174 = $186 over the cost with the carbon lamps and free renewals. In other words, the building owner using central-station current could not afford to accept the free lamps if carbon or gem lamps were furnished. The time is coming, however, when tungstens in the medium and small sizes will be furnished free as an inducement to use central-station service.

Tungsten lamps have now been developed to the point where they are comparatively substantial and can be used in any position and in almost every conceivable place. There are some places where no lamp will last its full rated life and in which the gem lamp will probably give longer service than the tungsten. Also where lamps are used for resistance, the carbon lamp has the advantage through its high current consumption. In other cases, however, the old type of lamp could profitably be replaced with the tungsten lamp even though it is almost certain to become broken before it has been in use its full rated life.

Our plant uses tungsten lamps exclusively in sizes from 25 to 150 watts and 200-watt gas-filled lamps, except a few 100-watt gem lamps for extension cords used in working around the engines and boilers. These tungsten lamps above 60 watts and some of the 40-watt lamps are left in service in the principal parts of the building until they begin to become dim, or at probably 500 hr. of use, at which time they are all replaced with new ones. These old lamps are then used in less conspicuous places around the power plant, where the decreased brilliancy is not so noticeable or essential, where they are used infrequently or where they are apt to become broken, as on the water-column drops, ashpits, in front of the boilers, etc. Incidentally it has been found cheaper to renew all the lamps in one hall or room at one time rather than one at a time as they burn out. This saves the electrician making more than one trip, carrying the step ladder, etc., with the possibility of breaking some or interrupting the occupants in the room. It also does away with the disagreeable effect of having parts of the lights bright and the rest dim. The packing boxes and tubes in which the lamps are received are saved and used for storing the partly burned-out lamps until wanted. This, to a large extent, prevents them from becoming broken in handling.

J. C. HAWKINS.

Hyattsville, Md.

How We Look to the Other Fellow

In the issue of Dec. 21, page 868, H. G. Schuler writes under the heading, "How We Look to the Other Fellow"—the other fellow in that case being a supply man. This letter suggests the following criticism:

First, with regard to the ambiguous manner in which the term "engineer" is used. I wonder sometimes, after reading some of the well-written articles regarding so-called engineers and their caprices, what an engineer really is or what he should be. I question whether the man who ordered a blowoff valve when a pop safety valve was wanted was in any respect an engineer. I presume the dictionary definition of an engineer would be one who runs or attends an engine, but what real engineer would say that this duty or his knowledge of the business ended there. I believe any real engineer can give the proper specifications relative to a valve, flange or fitting, or any other piece or pieces of power-plant equipment.

We all find it convenient to consult the manufacturer or supply man about some specific piece of apparatus that he has furnished, especially if complicated or intricate, and he should know all the details, but his duty is ended when such information has been furnished. I doubt very much if the average supply-house man can furnish details of power-plant equipment as well as the engineer in charge. I do not believe all the good engineers aspire to the supply man's position, but I think there are quite a number who have a combination of qualifications that would tend to make them good salesmen. It seems that an engineer having a pleasing personality combined with his knowledge of machinery, supplies, etc., and the usual live man's aggressiveness, should make an intelligent and successful salesman.

I have met a great many salesmen from the office forces of the manufacturing concerns they represented who knew but little more than enough to talk about the commodity they wished to sell, and the average engineer could give such a salesman valuable pointers about power-plant needs in general. Salesmen coming in contact with some of the successful engineers in charge of large plants will conclude that they are not only capable of ordering properly, but are business men of large caliber.

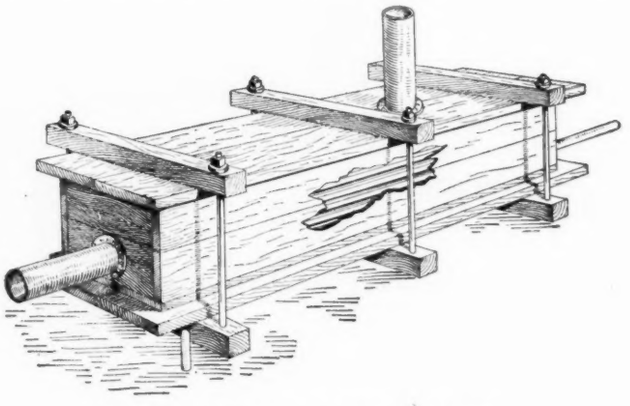
JOHN F. GORHAM.

Havelock, Neb.

Wooden Feed-Water Heater

In the engine room of a small planing mill I saw something I had never seen before in my 20 years' experience in engineering work. It was a wooden feed-water heater, made as shown in the illustration.

Some readers of *Power* may have seen such heaters, and if so, I would be pleased to hear from them. Under some



UNUSUAL FEED-WATER HEATER

circumstances this form of heater might be commendable. Probably the one that devised it could not get any other kind, so he deserves some credit, for it certainly is better than none. Nevertheless it is a curiosity.

St. Louis, Mo. H. R. ROCKWELL.

Inquiries of General Interest

Temperature Correction of Water-Meter Readings—When feed water at 98 deg. F. is measured by a meter that has been calibrated for giving the weight of water metered at 150 deg. F., what allowance should be made in determining the actual weight of water discharged through the meter? C. R. A.

Assuming that the volumetric error of the meter is the same at both temperatures, then for equal volumes the weights will be as the density or weight per unit of volume. Referring to the table, "Density and Volume of Water," given on pages 542-3 of the Oct. 19, 1915, issue of "Power," the weight for 1 cu.ft. of water at 98 deg. F. is 62.02 lb. and for 150 deg. F. is 61.1965 lb. Therefore to obtain the true weights the calibrated readings should be multiplied by $\frac{62.0200}{61.1965} = 1.0135$.

Advantage of Scalloped Cover Plate for Boiler Joint—What is the advantage of having a quadruple-riveted butt and double-strap joint with the outside cover plate saw-toothed? R. C. M.

With the inside and outside cover plates of the same width, the rivets are in double shear, so that the hoop tension brings a central load on the rivets; and to remove the objection of calking the outside cover plate along the long reach between the rivets of the outer row, as from A to B or B to C, in Fig. 1, the plate is scalloped or saw-toothed as in Fig. 2, so as to utilize the diagonal pitch of the two outer rows as a calking pitch.

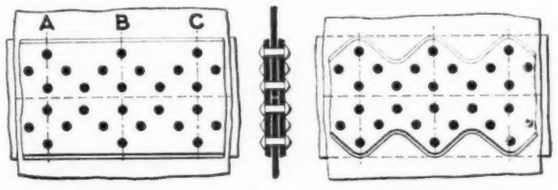


FIG. 1 FIG. 2

COVER PLATES FOR DOUBLE-SHEAR JOINTS

Estimating Heating Surface of Tubes—In estimating the heating surface of a boiler, should the fire or the water side of the tubes be taken as a measurement? L. L. S.

In computing the heating surface the actual surface against which the fire strikes should be reckoned, and not the surface in contact with the water. For greater convenience of making approximate estimates of the heating surface of fire tubes, it is a common practice to take the external in place of the internal diameter of the tubes, as the tubes are usually made in even inches or quarter inches in diameter, but in some cases, as in fire-engine boilers, where a large number of small fire tubes are employed, the assumption of external diameter in place of the actual dimension of the fire surface may make considerable difference.

Allowance for Quality of Steam—If the actual steam consumption of an engine is 36 lb. per i.hp. per hr. and the steam as received is 94 per cent. dry, what allowance should be made in rating the engine's consumption of dry saturated steam per indicated horsepower per hour? M. C.

In rating the steam consumption of an engine it is customary to charge the engine with the actual weight of dry steam used, although in most cases the presence of moisture in the steam delivered is of rather greater detriment to cylinder economy than the percentage of moisture in the steam. Therefore if the engine used 36 lb. of steam per indicated horsepower per hour and the quality of the steam was 0.94, the consumption of the engine would be rated as 94 per cent. of 36 = 33.84 lb. per i.hp. per hr. of dry saturated steam.

Working Pressure for Stayed Flat Surfaces—What is the rule for determining the allowable working pressure for flat surfaces of standard boiler plates when stayed by braces or stay-bolts? W. M. M.

According to the A. S. M. E. code for the construction of stationary boilers, the maximum allowable working pressure for various thicknesses of braced and stayed flat plates, when stayed with braces or stay-bolts of uniform diameter symmetrically spaced, shall be calculated by the formula,

$$P = C \times \frac{t^2}{p^2},$$

where

P = Maximum allowable pressure in pounds per square inch;
t = Thickness of plate in sixteenths of an inch;
p = Maximum pitch measured between straight lines passing through the centers of the stay-bolts in the different rows, which lines may be horizontal, vertical or inclined, inches;
C = 112 for stays screwed through plates not over $\frac{7}{16}$ in. thick with ends riveted over, and 120 when plates are over $\frac{7}{16}$ in. thick;
C = 135 for stays screwed through plates and fitted with single nuts outside of plate; and
C = 175 for stays fitted with inside and outside nuts and outside washers whose diameter is not less than 0.4p and thickness not less than t.

Unstayed Dished Heads—What is the formula for determining the proper thickness of unstayed dished heads for drums and other cylindrical pressure vessels? J. O. B.

According to the A. S. M. E. boiler code, the thickness required in an unstayed dished head with the pressure on the concave side, when it is a segment of a sphere, shall be calculated by the following formula:

$$t = \frac{5.5 \times P \times L}{W \times TS} + \frac{1}{8}$$

where

t = Thickness of plate, inches;
P = Maximum allowable working pressure, pounds per square inch;
TS = Tensile strength of the material, pounds per square inch;
L = Radius to which the head is dished, inches.

Where the radius is less than 80 per cent. of the diameter of the shell or drum to which the head is attached, the thickness shall be at least that found by the formula by making L equal to 80 per cent. of the diameter of the shell or drum. Dished heads with the pressure on the convex side are allowed a working pressure equal to 60 per cent. of that for heads of the same dimensions with the pressure on the concave side. The corner radius, measured on the concave side of the head, is not to be less than 1½ in. or more than 4 in., but not less than 3 per cent. of the radius to which the head is dished. When there is a manhole opening, the thickness is to be increased ⅛ in. and the opening is to be flanged to a depth of not less than three times the thickness of the head measured from the outside.

Boiler Tubes Split in Beading—In replacing several tubes of a horizontal return-tubular boiler, what would cause some of the tube ends to split when beaded over? R. H.

The tube ends that become split from beading may not have been properly annealed, the beading may not have been done gradually around the tube, or before any beading was done the tube ends may have projected too far beyond the flue sheet to be turned over without splitting.

Babbitt Metal Becomes Inferior by Remelting—Is babbitt metal rendered of less value for bearings if frequently remelted? C. A. V.

When babbitt metal has been remelted a number of times it loses its fluidity, becoming more "pasty" or "mushy" the oftener it is remelted, and will not make as sharp, smooth and solid castings for bearings as when the metal is new. This probably is due to separation of the ingredient metals resulting from oxidation of those of lower temperature of fusion, when raised to much higher temperatures than may be necessary for the fusion of other ingredients.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Standardization of Power-Plant Operating Costs*

By Walter N. Polakov

SYNOPSIS—Outline of a method by which the owner of a power plant can, without the necessity of study of technical details of operation, judge how close the actual performance of the plant is to the possible minimum cost at any time or under any circumstances, all variable factors beyond operating control being automatically adjusted.

The cost of manufacture of power, being a result of numerous factors involved in production, is the chief criterion upon which the market price, range of use, legislation, future developments, social welfare, etc., depend. Few if any of these questions can be intelligently answered from the knowledge of actual costs, owing to the effect of an unknown factor—degree of perfection of the actual performance. The importance of an accurate knowledge of the meaning and significance of actual cost data to the financier warrants the development of a method whereby a cost report tells what the power costs and should cost and where and why the loss has occurred. These questions answered, elimination of waste is a comparatively simple engineering problem.

Need of a dependable measure for financial efficiency of operation prompted managers and owners to compare their operating-cost data with those from other plants. An attempt to form an opinion whether one's operation is as economical as possible by such comparison with other plants whose equipment and service is more or less radically different would be absurd were it not for the want of a better method.

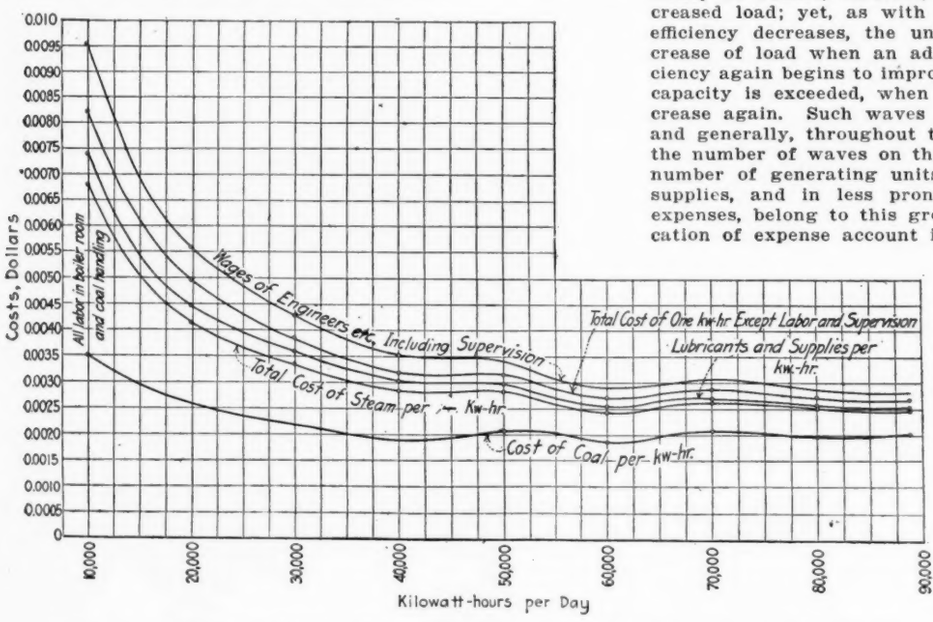


FIG. 1. CURVES SHOWING VARIATION IN STANDARD COSTS OF OPERATION IN A PUBLIC-UTILITY CENTRAL STATION

The most interesting attempt to devise means for more rational cost studies was offered by H. G. Stott and W. S. Gorsuch ("Transactions" A. I. E. E. 1913, Vol. II, p. 1619). Yet the use of various factors tending to compensate for differences in fuel, load factor of plant, labor cost, etc., are evidently inadequate. Prices per heat unit in shape of fuel, if adjusted, do not ascribe the differences in cost to either inherent efficiency of boilers, furnaces and stokers, or to the methods of firing and the personal element of attendance. The effect of load factor corrections is entirely offset by existing differences in the water rate of turbines and influences of auxiliary apparatus. Payroll correction factors established on the basis of mere payrates is erroneous, because of the size of units, floor plans, automatization of certain operations, etc. Even if these factors were correct, this method leaves the effect of supremacy of equipment efficiency unseparated from efficiency of methods of management. Finally, even if all factors are fully accounted for, the fact that one plant is equally economical to another does not tell how far each of them is from the possible degree of perfection.

All expenses incurred in power production fall under analysis into two main groups—constant (within a certain range) for any output and variable in some direct proportion with the output.

Expenses that are independent of volume of output are at the same time independent of each other and do not characterize the efficiency of processes performed in the plant. Their effect on unit cost is represented by a parabolic curve decreasing with the increase of output. They are exemplified by interest on investment, depreciation, sinking fund, insurances, management, payroll (in some cases), taxes, etc.

Expenses that vary with the output of the plant characterize, other conditions being constant, the efficiency of operation, and their elements stand together in dependent sequence. If represented graphically, they show very irregular-shaped curves peculiar to each set of equipment. Unit cost has a general tendency to drop with increased output, as the efficiency of boilers, turbines, etc., tends to improve with increased load; yet, as with higher degrees of overload, the efficiency decreases, the unit cost rises. With further increase of load when an additional unit is started, the efficiency again begins to improve until their cumulative efficient capacity is exceeded, when the unit cost commences to increase again. Such waves are sometimes very pronounced, and generally, throughout the range of the plant's capacity the number of waves on the unit cost curve is equal to the number of generating units installed. Fuel, water, certain supplies, and in less pronounced dependence, maintenance expenses, belong to this group of expenses, and for classification of expense account it is best to itemize them correspondingly to the steps in which the energy is transformed during the generating process. The criterion of economy is formulated by the interplay of three factors—time, product and cost. When only one factor varies, its effect on economy can easily be foreseen. Generally, however, all the factors vary simultaneously. The graphic method offers an easy means of solving the problem. To determine the economic limit reached by continuous increase or decrease of influential elements is not an easy problem, but unless it is solved we are in the dark not only as to what economy can be obtained, but also what changes in conditions and methods are essential.

It is imperative that the economy limit be established, as this is the only criterion for judging the actual performance. Carrying out the analysis of economy limit to its logical conclusion, the standard cost of product is arrived at, and evidently, during this investigation not only are itemized costs of individual partial processes found out, but the conditions and methods whereby standard cost can be attained are established. In other words, unless the standard costs are established, there is no measure of existing losses or exact knowledge how to eliminate them.

Manifestly, in determining the standard operating cost, such factors as inherent efficiency of equipment, its efficiency under different loads, prices of fuel and supplies, necessary and sufficient number of attendants and their compensation, etc., are already taken into consideration for a given plant. Any deviation observed between the actual operating cost and this standard cost indicates that some of the necessary condi-

*From a paper before the New York section of the American Society of Mechanical Engineers, Jan. 11, 1916.

tions were not lived up to, and it leads directly to the allocation of the loss to operating methods. On the other hand, any change in the basic data used in determining the standard cost being known, adjustment of the standard cost can be made before the blame is put on the operators. The efficiency of the thermo-dynamic process, domineering the operating cost in a power plant, should be made a subject of thorough investigation to ascertain first the maximum efficiency limit

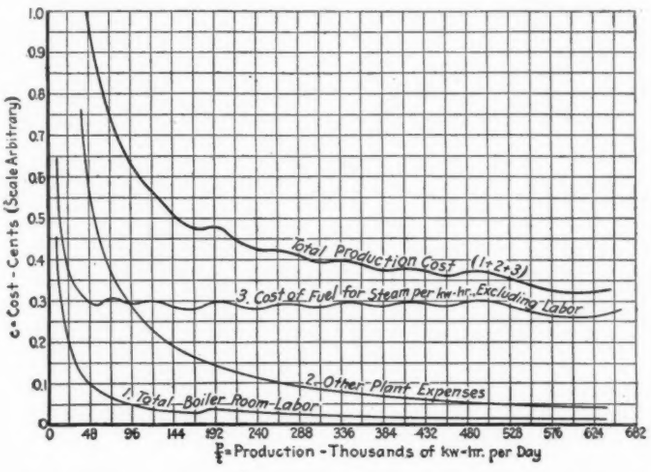


FIG. 2. VARIATION OF STANDARD COSTS OF POWER AT AN ELECTRIFIED RAILWAY CENTRAL PLANT

of each partial process, and then the result of their interplay. When this is accomplished, the entire process will be restudied for the purpose of standardizing methods and adjusting for such a balance of efficiencies of partial processes as will secure the maximum profit or economy from the expenditure of time, energy and money involved. When these limiting conditions are studied and determined, a method can be defined for each member of the working force, prescribing his duties and the conditions he must maintain to secure the most profitable degree of efficiency.

Upon the conclusion of these studies, the best efficiency of each unit and their combination being known for any load, the standard cost for any output in a given time unit can be conveniently represented in graphical form.

The principles of determining the standard cost of maintenance and upkeep of the plant and equipment are substantially the same; the method of study, however, is somewhat different. It involves a study of design and construction of all elements of equipment; minute records of their service and cost of maintenance may lead to a modification of design, use of cheaper renewable parts, etc. Next, the standardization of supplies, beginning in the laboratory and followed by actual service tests, helps to determine not alone the purchase price, but the lowest service cost. Finally, time studies embracing schedules for inspection, routes for maintenance men, standardization of tools, motions, methods, etc., conclude the investigation. The criterion is not the wages of the employee, but freedom from accidents, breakdowns and the lowest attainable cost of upkeep per unit of the plant's output.

Upon conclusion of this double analysis of the maximum economy obtainable, the graphs of standard cost of power production may be drawn. Curves may be conveniently arranged in the coördinates of cost C and product per unit of time $\frac{P}{T}$ (output). It will then be noted that the time element is one of the most influential factors in power economy. Whereas in some cases, where the number of generating units is large, the coal rate per unit of output remains fairly flat and the other items of cost reduce rapidly with increased production per unit of time, in other cases the standard cost of fuel also decreases as the time during which a certain output is produced is reduced. Figs. 1 and 2 represent curves of standard operating costs. Any number of curves may be plotted following the foregoing method, each representing an itemized standard cost according to the adopted classification. Fig. 1 is thus prepared for a medium-sized public-utility central station. It shows the variations of standard costs of coal, boiler-room labor, water, supplies, overhead charges, engineers and supervision per kilowatt-hour at various monthly outputs. The cost scale does not show, however, the actual standard. This plant comprises four 600-hp. boilers and three turbo-generators, one of 2,500 kv.-a. and two 500 kv.-a. rating; it operates 24 hr. per day, 7 days a week.

From this diagram it appears that the cost of coal per kilowatt-hour is lowest when the output of the plant is approximately 1,900,000 kw.-hr. per month. Further increase of output coincides with the increased cost for fuel required, owing to the characteristic of boilers and turbines that they lose in efficiency at higher rates of driving. Again, costs of labor, supplies, pro-rate overhead charges, etc., per kilowatt-hour, which drop more rapidly than the cost of fuel rises, offset the difference and render a greater monthly output more desirable economically. Even there, however, we meet a limit when at the rate of 2,200,000 kw.-hr. per month the unit cost becomes higher than it was at the lower output of 1,900,000 kw.-hr. per month.

Fig. 2 illustrates a few characteristic curves of standard cost per kilowatt-hour for various rates of output of a large central station feeding the lines of an electrified trunk railroad. The plurality of waves on the fuel-cost curve, etc., was explained before and the tendency of total standard cost to go steadily downward with increase of the output rate is due to the plurality of generating units.

Practical use of such predetermined standard costs can be made simple by these graphs. For busy executives or owners the entire cost record visualized by graphical representations of the items of account is found convenient. An example of such a graph is seen in Fig. 3, wherein the actual unit cost and the standard unit cost are plotted to the same scale, the deviation of one from the other suggesting at a glance the degree of perfection of the performance. The total-expense curve and the cumulative-expense curve may be shown on the same graph to a suitable scale; the latter curve is found serviceable for comparing these items with the appropriation made. A cost system kept on a card file in this manner will represent clearly in any desired detail for any length of time and at any period how much was spent, how much each unit of output cost and should have cost, what the fluctuations of expenses, unit cost and efficiency are and how close the actual amount spent in any time is to the appropriation. The accuracy of such graphic records is sufficient for most practical uses and references, as it allows the interpolation of unit costs to 0.001 of a cent. The exact total of expenditure can be had from the book records.

RIGHT BASIS FOR COMPARING PLANTS

Any comparison of production costs of various plants may now be made in a different light. By comparing standard costs of one plant with those of another, one learns how much cheaper power can be produced in one plant than in another, owing to its various physical advantages, corrections for load and output all being automatic. Again, by comparing how near the actual cost of one plant is to its standard cost with the difference between actual and standard cost of another plant, one has at once a measure of quality of methods and management. Thus, referring to Figs. 1 and 2, the actual cost per kilowatt-hour of 0.35c. in one plant means a worse operating efficiency than 0.48c. in another plant under another load condition.

The foregoing discussion does not include fixed charges borne by the plant. It is common to install in power plants considerable spare equipment, as a protection against breakdown and to take care of high peak loads. In both cases it would not be logical to adulterate production costs by adding all overhead charges incident to this idle equipment. If all charges due to policy, over-equipment, protection, spare units, new business anticipation and similar allied items are accounted where they belong—not against the operation—the cost of producing the current will appear constant unless prices of fuel, supplies, wages, etc., are changed or methods of management are not uniform.

Inasmuch as the spare equipment has a function identical to a stand-by plant at some distant point of transmission line or a breakdown emergency connection with a power company near-by, it seems proper to segregate charges of this sort and treat them like the bills of an emergency contract; that is, to carry the cost on a separate business account.

If, in a plant built and equipped to produce twice the output it normally carries, fixed charges are dumped together with operation costs, it reflects unfairly on the ability of the superintendent and his operating force; whereas if they were properly charged to a separate account, the excessive charge against the stand-by equipment, both for fixed charges and running expense, would produce a stimulus for new business, or commercial, or transportation departments to secure additional load.

The cost system developed along the lines discussed will not only afford a means for clear understanding of operating and managerial problems, but offer a basis for cost comparison of different plants. The essentials of knowledge gained through a comparison of actual cost in conjunction with the

standard are relative supremacy of plants proper, relative advantages of managerial methods, relative extent of preventable losses, relative advantages of prices of materials, etc. These cannot be found unless there is a comparable basis or scale for comparison, which is offered by standard costs determined for each plant individually, as at least ten main variables must be accounted for, as follows: Nature of load; character of service; conditions imposed by location; inherent efficiency of equipment; arrangement of equipment, floor plan, etc.; cost-efficiency of fuel and supplies; legal requirements; methods of operation; labor conditions, and methods of compensation for service. Each of these variables being a product of a plurality of factors, it is impossible to state, without carefully worked out standard costs, that the economy of one plant or another is satisfactory, or where and how it can be bettered.

Inasmuch as standard cost cannot be determined without first finding out how the maximum economy can be secured, the process of standardizing costs is also a process of devising the best way for operation and management. Once

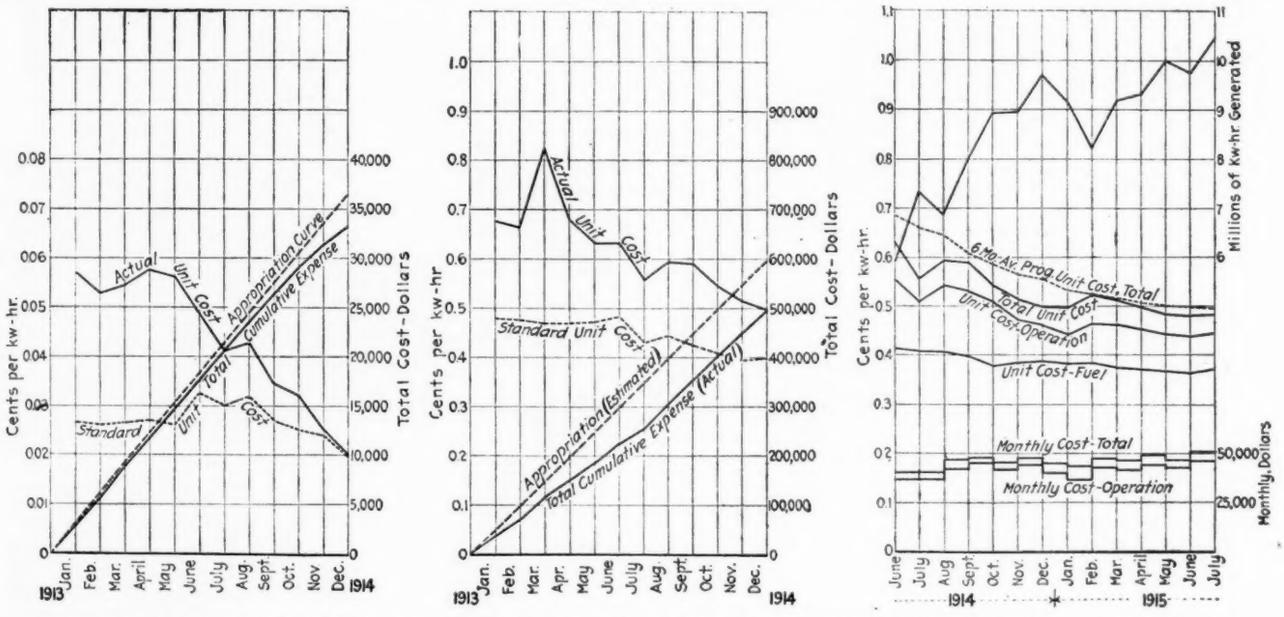


FIG. 3. VISUALIZED RECORDS OF THE ENTIRE COST OF POWER-PLANT OPERATION, IN WHICH THE ACTUAL UNIT COST AND THE STANDARD UNIT COST ARE PLOTTED TO THE SAME SCALE

both methods and results are positively established, costs are but the form of expression of the final result. It is true that the standard cost is influenced by the price of commodities used in the course of generation of power, as well as by some conditions beyond the control of the management and operating engineers, but the adjustment of the standard costs to every change of these factors can be made as simple as the use of a slide rule. Furthermore, a separate account should be kept for such charges as are the part of business policy.

Without predetermined standards, superintendents and managers will continue to believe that they control the production and owners will remain in happy ignorance as to how much of their money goes to waste and why. Only after the establishment of standards and ideal costs of production by the most rigorous analysis, will cost accounting be of help to engineers, and only then can it be said that the generation of power is directed by management and controlled by engineers.

DISCUSSION OF MR. POLAKOV'S PAPER

George L. Fowler thought it a hopeless task to attempt to get plant owners in the habit of finding out what their power cost. Referring to some personal investigations in a New England mill section, he had found the cost of power per horsepower-year to range from $28 to $150, owing to local conditions and to the character of operation. Most engine tests, he said, are made when the engine is in good condition and everything is primed up; in operation, however, it is different. In one case of an engine in which the equalization of load was out 15 per cent., a drop in efficiency of 22 per cent. resulted.

H. G. Stott took issue with Mr. Polakov in respect to the title of the paper. In his opinion it was not "standardization" but "segregation" that the paper aimed at; that is, it advocated treating each plant by itself, whereas standardization standard is to be established it should be made complete, including standardization of the coal, buying the coal on specification, standardizing supplies and, to a certain extent, labor. This leads to a series of accounts that might be handled to best advantage by a central-plant office, the expense of maintaining which would not be very large.

As to the proposition of figuring stand-by costs and charging them to separate accounts, he believed that if the load is such as to necessitate keeping a number of extra boilers on the line, and if it is to be compared with another plant in which there is a steadier load so that a smaller number of boilers need to be kept in reserve, it is unfair to charge this up against the operation of the former plant by directly comparing the coal per kilowatt-hour.

William Kent took issue with Mr. Stott, whom he believed had taken a rather narrow view of the subject, based perhaps on his own experience with the Interborough Rapid Transit Co. While complimenting Mr. Stott on the splendid performance of the plants of that company, he called attention to the support that had been given by the directors of the company, and through which Mr. Stott had been able to scrap a large investment in reciprocating engines and substitute turbines in order to gain a slight increase in efficiency. In the small plant conditions are entirely different.

Mr. Kent believed that the proper way with a small plant is to ascertain the performance of a number of plants in the same industry and plot these results against the size of the plant, making one curve for the best performances and another for the poorest performances. This would enable the owner or engineer to arrive at a standard for the best accepted practice in a plant of his size and character. The thermodynamic standard he did not believe practicable in the small plant.

J. W. Lieb thought that Mr. Polakov had confused production cost with the cost of power. The former, he said, should

not include any fixed charges, such as interest, depreciation and insurance, or general expense, but only the definite expense incurred within the walls of the power house; the cost of power, on the other hand, should include all of these items and perhaps some others, according to the conditions. He believed that, although much had already been done toward the classification of these items in the central-station industry, there is still much work to be done toward the standardization of plants having different outputs and different load factors. Whether the basis of the output that shall serve as the unit measurement of the production cost shall be the gross output of the generator, the gross output less auxiliaries, the gross output less excitation or less lighting and power within the power plant, or the net output delivered to the outgoing high-tension feeders is still a question to be decided. Also, considering the load factors as the basis of comparison between stations, there is no general agreement as to the time interval over which the so-called maximum demand shall be made. He believed it much preferable for one plant to be able to compare its performance with the best some other plant is doing, rather than with the best that can be obtained in that particular plant, possibly with inferior or antiquated apparatus.

He did not agree with Mr. Polakov in the statement that the business-getting department should be familiar with the fixed charges, or the extent of the reserve capacity of the plant; on the contrary, in the central-station business there is a pretty sharp line of demarcation between the commercial department and the department responsible for the maintenance of the proper and adequate reserve.

J. A. Kinkead sized up the situation by stating that there are two viewpoints to the proposition—the central-station and the isolated-plant viewpoints—the speakers having taken one or the other, accordingly as their work had been in one line or the other. There is no question at all, in his opinion, that the large central station can afford to throw out obsolete equipment and can employ the best brains in the country to operate its plant, because the units are so immense that a slight saving in percentage means a big saving at the end of the year. On the other hand, a smaller power plant cannot be so quick to discard "back-number" machines and put in new equipment; but it is of great importance to the users of small plants to know whether their plants are being operated under the most economical conditions. The idea of comparing the records of one month with those of another is all right if the engineer knows what his basic costs are and whether the costs he is figuring are as low as attainable under the conditions.

Cost of Heating Buildings*

Formulas for estimating the amount of coal for heating buildings have been in use for several years. The writer has used two of these formulas—that of E. F. Tweedy, of New York, and that of D. S. Boyden, of Boston. Mr. Tweedy's formula employs the glass and wall surface, giving a value obtained on a number of buildings in New York City. The corresponding ordinate gives the tons of coal per heating season. In the Tweedy formula, tons of coal per year $= \frac{W}{4.5} + 2G$, where W is the net wall surface and G is the glass surface.

Mr. Boyden's formula is somewhat complicated, but in the writer's opinion it has the advantage that it takes into consideration a difference in the operating conditions in the different buildings. Experience is necessary in the use of this formula, however, as serious errors are likely to affect the variables to such an extent that the calculated result will be far from correct. The formula follows:

$$\text{Tons of coal per year} = \frac{\frac{V \times a}{60} + (C_1 \times G) + (C_2 \times W)}{C_3 \times (130 - T)} \times L \times d \times h \times \frac{34}{e \times 2{,}000}$$

in which

V = Gross volume of the building, including basement, if heated;
G = Square feet of glass surface, 10 per cent. being added for north and west exposures;
W = Square feet of wall surface, 10 per cent. being added for north and west exposures;
a = Average air changes per hour during heating period;
C_1 = Constant for glass—1 for single glass;
C_2 = Constant for wall—usually 0.2 for brick and 0.3 for stone;
C_3 = Constant for local conditions—5.4 for Boston, 5.7 for New York;
T = Factor dependent upon the relation the heating plant bears to the premises heated;
L = Factor for portion of building not heated or for building heated to 70 degrees F.;
e = Average evaporation in pounds of steam per pound of coal;
d = Number of heating days during season;
h = Average number of hours of heating per day.

Under normal operating conditions, when steam is on the heating system for from 3,200 to 3,500 hours during the heating season of seven months, the two formulas agree fairly well with the actual results, as shown in the case of three buildings, as follows:

	Building		
	No. 1	No. 2	No. 3
Actual coal, net tons	655	486	1,572
Tweedy formula	625	380	1,500
Boyden formula	650	469	1,545

While the three amounts agree closely in the case of buildings Nos. 1 and 3, for building No. 2 the result by the Tweedy formula is much below the actual, probably owing to the fact that much heat was wasted through leaky windows, increasing the amount of air change per hour.

Among those in charge of building operation for the United States Government, the practice is followed of assuming the condensation of 500 lb. of steam per square foot of radiating surface per season. The writer believes this to be a safe figure, as in the case of the three buildings cited, the condensation approximated 400 lb., 430 lb. and 420 lb. per square foot per season respectively, assuming an evaporation of 7 lb. in each case.

The writer's method of estimating the coal requirements for heating a building is to employ the Tweedy formula and check with the Boyden formula and the Government method. A comparison of the results with the known requirements of a similar building completes the process.

While the amount of coal required depends largely on the amount of exposed wall and glass surface, yet it has been found that the total cost of operation bears a fairly well-defined relation to the volume of the building.

*From a paper by George W. Martin in the "Journal of the American Society of Heating and Ventilating Engineers."

Chicago N. A. S. E. Welcomes National President

On Tuesday evening, Feb. 1, the Chicago locals Nos. 1, 2, 28, 33 and 38, of the National Association of Stationary Engineers, held an enthusiastic meeting in the rooms of No. 1 to welcome National President Walter H. Damon. He was on his way back from Minneapolis, where with other national officers he had been making arrangements for the next annual convention. There was an unusually large attendance, and the enthusiasm displayed made the meeting one of the best ever held in Chicago.

National Secretary Raven conducted President Damon to the rostrum, and the latter spoke briefly on the affairs of the association. His hobby was propagation work. There should be more money expended to secure new members. The association has 23,000 members, but there is no reason why this number should not be increased to 50,000 if the engineers of the country were properly canvassed. While education was the keynote of the association and all the money that could be spared should be devoted to this end, still he believed that a proper division of the fund had not been made.

John F. McGrath spoke of the suit in which the association was now engaged, the tying up of funds and the possible reduction of the mileage allowed for the national convention at Minneapolis. As to education, it was the hobby of the association. They had perhaps spent more money on lantern slides than was really necessary, but it was only an experiment. The slides had proved of great interest and value, and as they were now paid for, it would not be necessary to spend so much in future.

Bert Hesse, president of Illinois No. 38, the association that has made the greatest record of any in the country during the past year, by increasing its membership from 60 to 92, was the next speaker. This association has made strong efforts along educational lines. Other things less desirable have been eliminated to make way for education, and as much time as possible has been devoted to this end.

John W. Lane, editor of the "National Engineer," spoke of the career of Walter Damon, who had won his way up from a coal wheeler to be chief engineer of a great station. Mr. Lane discussed the question of revenue and suggested that

at future conventions those members proposing a certain convention city should have estimates ready as to what the mileage would cost. All conventions should be held at the center of membership. In this way the mileage would be held down to a minimum of, say, $15,000, making it unnecessary to increase the revenue and leaving a considerable balance to devote to purposes other than mileage.

President Cotterman of No. 28 believed in friendship and fraternalism. It was his opinion that the engineers should get together oftener in a socjal way, that they should visit plants and that they should spend more time in becoming better acquainted.

Mr. Parker, from Illinois No. 49, of Elgin, came out strongly for more propagation work. He, for one, was willing to pledge all that he could to help build up the state and local associations to their full quota, and it was his hope that there might be more money available for this purpose.

Mr. McCoy, who had come all the way from Winona to see the national president, thought that there should be no let-up on the educational work and that it should be extended to fields outside of engineering.

In the opinion of Henry Misostow, chairman of the Illinois State Association, the state organization was the heart of the national body. This organization knew what was best for the engineers in each particular state, and if it was desired to know what the national association should be and what it should do, the places to go for the information were the state organizations. President Damon agreed that the state association was of prime importance. He believed that each state should take care of its own members and that the state organization should be self-supporting. It should not draw on the national body for revenues to carry on educational work and agitation for license and inspection laws. In fact, it was his contention that the national convention should be made up of state representatives. In this way the expense for mileage would be greatly curtailed and there would be an abundance of money to devote to other purposes.

Charles Naylor thought that the N. A. S. E. was doing as well as at any time in the past. It was giving the men who joined it just what it proposed to do, provided they had any intelligence. It was his special plea that young men especially should come in to the organization. It would help them, and in the way of education they would get just what they went after.

Frank Leeson spoke briefly on the life and accident department and Jacob Rietz, of No. 1, told of the good work the ladies' auxiliary was doing, mentioning particularly the starting of the pension fund, which at the present was caring for the needs of a number of engineers.

Alfred Johnson spoke on educational work and the monetary advantage that might be gained by boosting the "National Engineer." The lantern slides had been of material benefit and had been greatly appreciated by the various state locals.

With brief remarks by Al. Haydeen and Fred Gielow, stories by Joe O'Connel and Fred Hickey and a parting word by President Damon, the meeting was brought to a close.

PERSONALS

Lewis W. Young, for eighteen years chief engineer for the J. W. Strieder Co., Boston, Mass., is now chief engineer for the Renfrew Manufacturing Co., Adams, Mass.

Herbert Coward, for three years in charge of the Spiro turbine department of the Buffalo Forge Co. and for four years previously engaged in sales and engineering work in connection with air-conditioning apparatus, has been appointed steam engineer of the Carrier Engineering Corporation and is now located at its main office, 39 Cortlandt St., New York City.

Ashley P. Peck has resigned as Chicago district sales manager for the Terry Steam Turbine Co. and Smith-Serrell Co., Inc., having been appointed construction engineer for the Thos. B. Jeffrey Co., automobile builders, Kenosha, Wis., with direct supervision of all operating conditions and new construction. Mr. Peck was with the New York office of Allis-Chalmers Co., as district engineer, removing to Chicago to represent the Terry interests in the Middle West.

Thomas F. Williams, formerly chief mechanical engineer of the Aëromarine Plane and Motor Co., Avondale, N. J., and a specialist in carburization of fuels, has accepted the position of chief consultant of the Board of Engineering Research, Mechanical Applications, of the Powdered Coal Engineering and Equipment Co., of Chicago, and will direct the research work of that company in the carburization of comminuted fuel and the application of automatic mechanical regulation and controls thereof.

NEW PUBLICATIONS

THE "MECHANICAL WORLD" POCKET DIARY AND YEAR BOOK FOR 1916. Published by Emmott & Co., Manchester, England, and for the United States by the Norman, Remington Co., 308 North Charles St., Baltimore, Md. Size 4x6 in.; 335 pages; illustrated by charts and diagrams. Price, 25c.

This twenty-ninth annual issue of the "Mechanical World" pocket diary and year book for 1916 appears in its familiar form, but containing several new features. The section on boilers and boiler settings is greatly improved. A separate section is devoted to the Diesel type of internal-combustion engine. Several new tables have been added and others extended, and the work has been thoroughly revised throughout.

THE ELECTRICAL BLUEBOOK. Published by the Electrical Review Publishing Co., Chicago. Size, 10x7 inches; 256 pages; illustrated. Price, $2.

This is the seventh annual edition, containing a list of approved electrical fittings and materials and the revised National Electrical Code, fully illustrated, the changes in the latter standing out in bold-face type. An additional section contains the "Code of Professional Conduct of the American Institute of Electrical Engineers," treatment for electrical shock, an article on ground detectors and a street-lighting schedule for 1916, as compiled by the "Electrical Review and Western Electrician." As did its predecessors, this edition should serve as a useful reference for all those engaged in electrical construction and wiring.

ENGINEERING THERMODYNAMICS. By Professors J. A. Moyer and J. P. Calderwood. Published by John Wiley & Sons, Inc., New York City. Cloth; 203 pages; 70 illustrations. Price, $2.

In the introductory chapter the general scope of thermodynamics is outlined and the important engineering units are defined. The simplest imaginable example of heat engine is taken as that which has for its working substance a long rod of brass, which is heated and cooled and arranged to operate as the pawl of a ratchet wheel. Some actual form of heat engine used as an example in the introductory chapter would prove of greater value in interesting the student in the subject matter.

The laws of perfect gases, including the derivation of formulas for the various thermal lines, are clearly treated in Chapters II and III.

The application of the laws of gases to gas cycles is incompletely discussed in Chapter IV, which has the misleading title, "Cycles of Heat Engines." In this chapter are considered only the Carnot and the regeneration air-engine cycles. No mention is made here or in any other part of the book of the various internal-combustion engine cycles, including the Lenoir, the Otto, the Brayton and the Diesel. In a textbook on "Engineering Thermodynamics" some space should be devoted to the analysis of the possible and practical heat-engine cycles using gas.

One chapter is devoted to the properties of steam and to the use of steam tables. This chapter is very clear, but somewhat incomplete.

The chapter on the properties of steam is followed by one on "Practical Applications of Thermodynamics to Thermal Machinery." This title is somewhat vague. The subject matter of this chapter includes the fundamentals of air and vapor refrigerating machines as well as compressed-air machinery. This chapter is inserted between the chapters on the properties of steam and of the steam-engine cycles. A chapter of this type near the end of the book and with a title, "Refrigeration and Compressed-Air Machinery," would be more suitable.

Chapter VII is devoted to entropy of perfect gases and of steam, and this is followed by a chapter on the "Practical Steam Expansions and Cycles." The first part of this chapter is devoted to steam expansions and to the Rankine cycle.

This is followed by the application of the temperature-entropy diagram to the analysis of the steam engine. The authors then work out problems on the efficiencies of various heat engines. All the engines in the problems given operate under dissimilar conditions, making a comparative study of the merits of different types impossible. Some attention is also given in this chapter to Hirn's analysis.

The last chapter is devoted to the subject of flow of fluids through orifices and nozzles. The various chapters include many well-selected and practical problems.

In general the book is clearly written, but the attempt to make this treatise brief resulted in the omission of important details. A somewhat more careful arrangement of the subject matter and the addition of the modern internal-combustion engine cycles would serve to add to the value of this book.

New Brunswick Boiler Explosion

At 9:30 a.m. Wednesday, Feb. 2, a return-tubular boiler in the plant of the Howe Rubber Co., New Brunswick, N. J., exploded, killing two men, injuring four and doing $50,000 damage to the property by impact and fire.

The boiler was 60 in. diameter by 14 ft. long and operated at 70 lb. pressure to supply steam to pumps and vulcanizers. It was second-hand when purchased five years ago; its age is not known. The shell plates were $\frac{5}{16}$ in. thick, except a new $\frac{3}{8}$-in. plate which was lately put in the lower half of the front course over the fire. The heads were $\frac{1}{2}$ in. thick. The longitudinal seams were of double-riveted lap construction; the girth seams were single-riveted. The plates were wrought iron, the fractures showing laminations, but the layers were not separated—that is, there was no blistering. No evidence of pitting was visible, and there was very little general corrosion.

The explosion tore off the rear end at about the middle of the third course, the front, or large part, of the boiler being blown through the building, landing 40 ft. away; most of the tubes went with this part. The back head and strip of plate from the third course were blown 60 ft. in a direction opposite to that taken by the larger part of the boiler.

The immediate cause of the explosion was overheating around the blowoff outlet, due perhaps to detached scale being deposited there. Two explosions were heard, the first being little more than a hissing of steam, the second, the big blow-up.

The boiler was under repairs on Sunday and was filled Sunday night and operated Monday and Tuesday. The tubes show no evidence of having been overheated. The coroner did not think it necessary to hold an inquest.

Recent Court Decisions

Digested by A. L. H. STREET

Contributory Negligence of Electrician—There can be no recovery against the employer of an electrician for the latter's death by electrocution while connecting a motor to its service wires, when it appears that he carelessly neglected to protect exposed ends of the wires with temporary insulation or to adopt another safeguard, knowing that the wires were connected with a power wire which carried a fatal voltage. (Maine Supreme Judicial Court, Royal vs. Bar Harbor & Union River Power Co., 95 "Atlantic Reporter," 945.)

Discrimination in Power Service Rates—A public-service corporation engaged in furnishing electric current for power purposes may not lawfully charge a given customer a higher rate than is charged another for the same service under similar conditions, according to the view taken by the United States District Court for the Southern District of Iowa, in the case of Homestead Co. vs. Des Moines Electric Co., 226 "Federal Reporter," 48. And it is decided that this decision is not to be affected by the fact that the higher rate may be less than that which might lawfully be charged all customers. But the opinion leaves it quite uncertain as to just what damages are recoverable for such discrimination, declaring that they are to be measured by the loss proximately resulting to the aggrieved customer as a direct consequence of the discrimination, which was found in this case not to be the difference between the two rates. Following a late decision of the Minnesota Supreme Court, the United States District Court holds that the reasonableness of a discriminatory rate will not be passed upon by a court at the instance of an individual consumer, if it appears that the rates charged do not exceed the maximum prescribed by ordinance or other authority. In other words, the question should be determined in a suit brought by the attorney general or a county attorney for the public benefit.

ENGINEERING AFFAIRS

International Union Steam and Operating Engineers, Local No. 2, St. Louis, held memorial services for the late John P. McDonough, of that city, on Saturday evening, Jan. 29, in the Holland Building Hall, J. W. Wood, president of No. 2, presiding Other addresses of tribute were made by Dr. W. W. Boyd, S. A. Webster, James C. Shanessy and Louis P. Aloe.

Lectures on Military Engineering—A course of seven free lectures on military engineering will be given under the auspices of a committee representative of the four national engineering societies, by Captains Robins, Coiner and Ardery, Corps of Engineers, U. S. A. This course will be under the direction of Maj.-Gen. Leonard Wood and is designed to assist those who desire to enter the engineering battalion that will be formed at Plattsburg next summer. All engineers interested in preparedness will be welcome, but attendance at these lectures does not imply obligation to subsequent camp duty. Through the coöperation of the United Engineering Society, the auditorium of the Engineering Societies Building has been placed at the disposal of the army officers. The lectures will begin on Monday, Feb. 14, 1916, at 8 o'clock and will continue every Monday thereafter until the completion of the course. It is hoped that Major-General Wood will be able to address the first meeting.

BUSINESS ITEMS

The Eastern Pennsylvania Power Co. is to have a new station at Dover, N. J. Mr. Peterman is the general superintendent and Mr. Yensel is the local manager.

To take care of its increasing business in New England the Richardson-Phenix Co., lubrication engineers and manufacturers, Milwaukee, Wis., has recently opened a branch office in Boston, Mass., located at 141 Milk St. This office will be in charge of Charles E. Blake, who has had many years' experience with this company in the design and installation of power-plant lubricating systems. The New York office of this company has been removed to 30 East 42d St. E. M. May, manager of this office, now has associated with him J. J. May, who will devote his energies to the Richardson-Phenix NoKut valve department.

The two Spray Engineering Co. air washers and coolers installed by the Spray Engineering Co., Boston, Mass., as auxiliaries to the 35,000-kw. and the 30,000-kw. steam turbo-generator sets in the new A-2 Christian St. station of the Philadelphia Electric Co., are for what is believed to be the largest pair of units in the world. Other recent installations of the Spray air washers and coolers are the following: Lawrence Gas Co., Lawrence, Mass.; Lynn Gas and Electric Co., Lynn, Mass.; Cambridge Electric Light Co., Cambridge, Mass.; United Electric Light & Power Co., New York.; National Conduit and Cable Co., Hastings, N. Y.; Commonwealth Edison Co., Chicago, Ill.; Consolidated Gas, Electric Light and Power Co., Baltimore, Md.; Merchants Heat and Light Co., Indianapolis, Ind.; Toledo Railways and Light Co., Toledo, Ohio; Public Service Electric Co., Essex, N. J.; North American Chemical Co., Bay City, Mich.; Evansville Public Service Co., Evansville, Ind.; Eastern Pennsylvania Railways Co., Palo Alto, Penn.; Minneapolis General Electric Co., Minneapolis, Minn.; New Orleans Railway and Light Co., New Orleans, La.; Mobile Electric Co., Mobile, Ala.; Lowell Electric Light Corp., Lowell, Mass.

Classified Ads

Positions Wanted	**Wanted**
Positions Open	Agents and Salesmen
Civil Service Work	Contract Work
Employment Agencies	**Miscellaneous**
Labor Bureaus	Educational
Business Opportunities	Books
For Sale	**Proposals**

RATES: Positions Wanted, 3 cents a word, minimum charge 50 cents an insertion, payable in advance. Other advertisements, 5 cents a word, minimum charge $1.00. Count 4 words for blind address care of our New York or Chicago offices. Advertisements for bids $3.60 an inch.

ANSWERS addressed to us at 10th Ave. and 36th St., New York or 1144 Monadnock Block, Chicago will be forwarded without charge (excepting circulars or similar literature).

IMPORTANT: Original letters of recommendation or other papers of value should not be enclosed to unknown correspondents—send copies. Advertisers' names will not be furnished under any circumstances. Copy received until 10 A.M. Tuesday for following Tuesday's issue. P

Note: Copy for the issue of Feb. 22 is required one day earlier than noted above.

POSITIONS OPEN

TWO OPERATORS wanted, one repair man who can set valves on twin-tandem gas engines, for an electric power house in Pennsylvania. P705—Power.

SEVERAL FIRST-CLASS DRAFTSMEN wanted at once, of general mill and blast furnace experience; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P687—Power.

SEVERAL DRAFTSMEN wanted at once, experienced in power plant and general piping work; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P688—Power.

AN ASSISTANT ENGINEER wanted in large power plant near Philadelphia; must be able to prove experience in operation of the leading turbines, Corliss engines and boilers; must have machine-shop experience and be willing to work. P694—Power.

MAN wanted to take charge of erection and maintenance of machines and power equipment in tannery located in small town near city; permanent position for the right man; in answering give full particulars regarding age, experience and salary considered. P696—Power.

Employment Agencies

CORRESPONDENT

THE UNDERSIGNED plans and conducts correspondence for positions in technical, manufacturing and prcfessional lines; $2500 to $15,000 men exclusively; complete privacy assured; no commission charged—only service fee and postage. Send name and address only, in confidence, for prefatory details. R. W. Bixby (established 1910), P1 Niagara Square, Buffalo, N. Y.

POSITIONS WANTED

CHIEF ENGINEER open for position; 20 years' experience; present position 5,000-hp. plant; best of reference. PW703—Power.

POWER-PLANT OPERATING ENGINEER or assistant; licensed man; experienced in the care and operation of engines, boilers and auxiliary equipment; immediately available; location immaterial. PW678—Power.

CHIEF ENGINEER in a small plant or operator in a large plant; 12 years' experience with steam, electric, refrigerating, pumping and condensing equipment; technical education; first-class license and references; married; age 31; employed. PW706—Power.

MECHANICAL ENGINEER, with engineering and operating experience in connection with large steam-power plants, desires position such as power or mechanical superintendent or chief mechanical engineer; now holding executive position. PW708—Power.

MECHANICAL ENGINEER, Columbia, expert on equipment used by chemical and allied industries, good executive with ten years' practical experience in purchase, construction, installation, efficient management and maintenance; last six years in charge engineering department of one of the largest chemical works in United States, desires change. PW709—Power, Chicago.

MARINE ENGINEER, licensed as chief engineer of ocean vessels, now serving as first assistant on a steamship, familiar with the operation of large units, refrigerating machinery, oil fuel, construction of machinery, desires position ashore as chief engineer of small plant or assistant in large one; location immaterial; would like correspondence regarding position open about July 1. PW699—Power, Chicago.

COMBUSTION ENGINEER wants to communicate with a company burning large amounts of fuel in regard to position; only large concerns can be considered and would prefer one with headquarters in New York City; is at the present employed by a large industrial concern in Middle West, where he is very successful in obtaining large savings. Savings of from 10 to 30% can be obtained by specialists in standardizing methods of operation in power plants. What would this percentage amount to in your case? Write for full particulars and references. PW702—Power, Chicago.

WANTED

MANUFACTURER wants either patented or patentable ideas on boiler and engine room specialties; cash or royalty basis. W676—Power.

STEAM TURBINES—Chicago steam and hydraulic machinery house desires to add line of steam turbines. Correspondence from manufacturers with ample facilities requested. W701—Power, Chicago.

AGENTS AND SALESMEN

AGENTS to handle boiler-efficiency device; liberal commission and full coöperation. W686—Power, Chicago.

AGENTS wanted to handle a new patented grate bar on commission; state experience, location, how long established. W685—Power.

SPECIALTIES, high-grade mechanical, preferably boiler or heating; reliable firm will handle in and around Indianapolis. W707—Power, Chicago.

REPRESENTATIVES for a new type of a thoroughly established and successful steam specialty; state experience and territory covered. W629—Power, Chicago.

SALES AGENCY for western New York can handle a few more mechanical appliances of merit. W704—Power.

AGENTS handling engine and boiler room specialties, in every section, for side line, paying large commissions. Give experience, lines carried and territory covered. W390—Power.

MISCELLANEOUS

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

PATENT ATTORNEYS

PATENTS. C. L. Parker, patent attorney, formerly member Examining Corps, U. S. Patent Office, McGill Bldg., Washington, D. C. Inventor's handbook sent upon request.

IS YOUR INVENTION VALUABLE? Ask A. P. Connor, electrical, mechanical engineer (ex-chief electrical engineer for New York). Patent attorney. Lawyer. Carroll St., S. E., Washington, D. C.

For Sale

Second Hand Equipment

Rates: Less than 4 insertions 75 cents per line—4 to 11 insertions 70 cents per line—12 or more insertions 65 cents per line

Equipment Wanted items appear at the end of this list.

ADVERTISERS' NAMES are abbrevinted in most of these items. Complete names and addresses are as follows:

MANHATTAN Rubber Mfg. Co., Passaic, N. J.—All equipment advertised may be seen in daily operation at the company's plant. Delivery Mar. 15, 1916, f.o.b. D., L. & W. R.R., Passaic.

NEW RIVER CO., The, MacDonald, W. Va.

STANDARD Tool Co., The, Cleveland, Ohio.

BOILERS

2 Class E-7 Sterling water tube, 150 hp. each, 1,500 sq.ft. heating surface, 3¼" tubes, pressure allowed, 150 lb.; 2 Erie City return tubular 18' long, 72" dia., 70 4" flues, 150 hp.—WHEELING.

ENGINES, GAS

Westinghouse vertical, 40 hp., now running; in best possible condition. Selling because of purchase of a larger unit. Delivery immediately.—The Acklin Stamping Co., Toledo, O.

ENGINES, STEAM

Horizontal and Vertical, capacities 6 to 320 H.P. All good makes.—NEW RIVER.

1—14"x36" Allis-Chalmers Corliss, 1890 type, R.H., fine condition.—L. F. Seyfert's Sons, Inc., 437 N. 3rd St., Phila., Pa.

Fitchburg left hand, horizontal, tandem compound; cylinders 17" and 28" dia., 36" stroke, 120 r.p.m., heavy tangye frame; double ported piston valves; flywheel 14' dia., 24" face, with governor and outboard bearing, $3,000.—MANHATTAN.

One 500 h.p. Bates Corliss Cross Compound Condensing Engine and one 400 h.p. Buckeye Tandem Compound Horizontal Engine. Both engines in first-class condition and must be sold at once.—Wabash Portland Cement Co., Ford Bldg., Detroit, Mich.

American Ball Engine 160 HP. 16"x14", 250 R.P.M. with belt wheel 72"x15", new, was never set on foundation.—F. S. 693—Power.

Erie City autom. cut-off, 15" cyl., 14" stroke.—STANDARD.

Hamilton Corliss, 20¼" cyl., 42" stroke, flywheel 16'x32".—STANDARD.

GENERATING UNITS

Direct current, 250-500 V., cap. up to 250 KW.—NEW RIVER.

One 220 KW., A.C., 60-cycle, 2,200-volt, two-phase generator, direct connected to 200-r.p.m. Buckeye engine, with transformers for supplying 2,200 volts, 3-phase, complete with barometric condenser, motor-driven condenser pump, switchboard instruments and instrument transformers. Complete details upon application to WISCONSIN GAS & ELECTRIC CO., Racine, Wis.

Engine and Generator—One Hamilton 19x36x42" horiz. tandem compound Corliss engine, shop No. 2649 L.P., with 14x16" c.-i. flywheel; mfd. by Hooven, Owens, Rentschler Co., Hamilton, Ohio. D.C. to Westinghouse 580-kw. generator, 440-v., 761 amp., 3-phase, 25-cycle, 107 r.p.m.; No. 453,419; mfd. by Westinghouse Electric & Mfg. Co., Pittsburgh, Pa. Equipment has been in operation 5 yr. and can be seen at our Cedar Rapids mill. For price and full information address National Oats Co., St. Louis, Mo.

One cross-compound Buckeye engine with high-pressure auxiliary cylinder attached; can be used condensing or non-condensing for steam or hot-water heating. The size of this engine is 18¾" dia. high-pressure cylinder, dia. low-pressure cylinder 36", stroke 33", r.p.m. 138; auxiliary cylinder 14½" dia., 33" stroke. This engine is direct connected to a Westinghouse revolving field type, 2,300 volt, 400-kw., 60-cycle, 2-phase generator. Also one tandem compound Buckeye engine, 20x 36x33, 138 r.p.m., direct connected to 400-kw. Westinghouse surface wound armature, type 2-phase, 60-cycle, 2,300-volt generator.—Iowa Railway & Light Co., Cedar Rapids, Iowa.

GENERATORS

Sprague belted, D.C., type S, 150 kw., 120-125-V., 1,200 amp., 550 r.p.m., with base, slide rails and voltage regulator, $800.—MANHATTAN.

PIPE AND FITTINGS

Pipe and fittings, screwed & flanged, 7 to 18".—NEW RIVER.

PUMPS

High head, general service and boiler feed.—NEW RIVER.

WANTED

Boiler—One 300- to 400-hp. B. & W.; must be in good condition; give full particulars. W705—Power, Chicago.

Generating unit—120-V. D.C. generator, direct connected to steam engine, 25 to 40 kw.—City Laundering Co., Oelwein, Ia.